

**DESIGN AND DEVELOPMENT OF AN IMPROVED LOW-COST CERAMIC WATER FILTER
BASED ON THE EXISTING POTPAZ HOME WATER TREATMENT DEVICE FOR USE
WITHIN RURAL HOUSEHOLDS OF THE VHEMBE REGION**

by

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DECLARATION BY CANDIDATE

I hereby declare that the dissertation submitted for the degree MTech: Industrial Design, at the University of Johannesburg, is my own original work, has been edited and has not previously been submitted to any other institution of higher education. I further declare that all sources cited or quoted are indicated and acknowledged by means of a comprehensive list of references.



Martin Bolton

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ABSTRACT

This project aimed to develop the Potpaz ceramic water filter into an improved filter design optimally suited to South African rural conditions, to provide potable water rather than contaminated water to households. Communities that do not have access to in-house treated water often end up with a contaminated water supply, as the water to be consumed is usually sourced from communal water collection points and stored in containers. There is evidence that the water consumed at point-of-use in rural areas is not always of a potable quality due to possible contamination between collection and consumption. The existing Potpaz home water treatment device has been scientifically proven to return contaminated water to a potable state. A limited number have been imported to South Africa for use in a project that studied the effect of household point-of-use treatment on the health of the consumer. It was not at all certain whether the households would use these devices effectively because this filter was not part of their everyday water system. Part of investigating whether or not they would effectively use this filter was the inclusion of industrial design within the filter assessment section of a larger research project conducted in the Vhembe region to understand the requirements of the user. Industrial design concerns itself with the requirements of the user, as well as knowledge regarding product design, development and manufacturing. Households that took part in the point-of-use project used the Potpaz home water treatment device for more than two months and were approached to provide feedback regarding its use. From the feedback, it became evident that there were aspects of the Potpaz design that needed modification towards an improved water filter more suited for its intended use in rural households. An Action Research-influenced methodology and User Centred Design approach informed the collection of original data and feedback on areas of improvement. This, together with visits to local shops and community potters, provided sufficient background to understand the needs and preferences of the intended rural users regarding the use of the device. This informed the design process and increased the chances of developing a readily accepted, more suitable product to the intended users and the domestic environment in which they live. To achieve this, this project focused on the following aspects regarding Potpaz filters: placement, use and design aspects of usability and ergonomics. Development of the improved filter design culminated in rapid prototyping of a scale model and the fabrication of a full-size working model allowing for physical interface to evaluate the success of the design solution.

TABLE OF CONTENTS:

| | PAGE | | |
|---|----------|--|--|
| ACKNOWLEDGEMENTS | iii | 3.3.4.3 | Conclusions of flow-rate testing 18 |
| ABSTRACT | iv | 3.3.5 | Self-assessment forms 18 |
| TABLE OF CONTENTS | v | 3.3.5.1 | Process of collecting self-assessment data 19 |
| LIST OF FIGURES | vi | 3.3.5.2 | Table 2. Results from self-assessment form data 19 |
| LIST OF TABLES | viii | 3.3.5.3 | Conclusions from self-assessment form data 19 |
| LIST OF ANNEXURES | viii | 3.4 | Field research 20 |
| CHAPTER 1: CONTEXT, PROBLEM STATEMENT AND RESEARCH OBJECTIVES | 1 | 3.4.1 | Data gathering tools utilised 20 |
| 1.1 Context | 1 | 3.4.2 | Field research analysis, conclusions and possible solutions 22 |
| 1.2 Background | 2 | 3.4.2.1 | Analysis of placement (location in the house) 23 |
| 1.3 Research objectives | 3 | 3.4.2.2 | Analysis of design aspects 29 |
| 1.4 Problem statement | 3 | 3.4.2.3 | Analysis of use 37 |
| CHAPTER 2: LITERATURE REVIEW | 4 | 3.4.2.4 | Spaza shop visits 46 |
| 2.1 Introduction: The point-of-use project | 4 | 3.4.2.5 | Potter visits 48 |
| 2.2 Studies of water filters in rural households | 4 | 3.4.2.6 | Personal observations 48 |
| 2.3 Studies of the Potpaz filter | 4 | 3.5 | Synopsis 50 |
| 2.4 Advantages and disadvantages of the Potpaz filter | 5 | CHAPTER 4: DESIGN REQUIREMENTS FOR THE IMPROVED WATER FILTER, CONCEPTUALISATION, FINAL DESIGN | 51 |
| 2.5 Synopsis | 5 | 4.1 | Introduction 51 |
| CHAPTER 3: RESEARCH METHODOLOGY, DATA COLLECTION, RESEARCH RESULTS AND DATA ANALYSIS | 6 | 4.2 | Design requirements 51 |
| 3.1 Introduction | 6 | 4.2.1 | High Priority: Primary design requirements 51 |
| 3.2. Research methodology | 6 | 4.2.1.1 | Considerations for manufacturing and distribution 52 |
| 3.2.1 Products designed with assistance from the intended user | 8 | 4.2.1.2 | Existing strong-points of Filtron filter 52 |
| 3.3 Data collection | 8 | 4.2.2 | Medium Priority: Secondary design requirements 53 |
| 3.3.1 Background research | 8 | 4.2.3 | Low Priority: Tertiary design requirements 53 |
| 3.3.2.1 History of the Potpaz filter | 8 | 4.2.4 | Synopsis 53 |
| 3.3.2.2 The effectiveness of the Potpaz filter | 9 | 4.3.1 | Conceptualisation: Concept one 54 |
| 3.3.2.3 Added effectiveness with the application of colloidal silver | 9 | 4.3.2 | Conceptualisation: Concept two 57 |
| 3.3.2.4 Composition of the assembled Filtron filter unit | 10 | 4.3.3 | Conceptualisation: Concept three 60 |
| 3.3.2.5 Manufacturing and assembling the Filtron filter | 10 | 4.3.4 | Elements to include in the final design 63 |
| 3.3.2.6 Operation of the Filtron filter unit | 12 | 4.4 | Design development 64 |
| 3.3.2.7 Manufacturing of components | 12 | 4.4.1 | Developmental prototype: stability test model 64 |
| 3.3.2.8 Covering lid and filter retaining ring | 12 | 4.4.2 | Conclusions from the stability test model 66 |
| 3.3.2.9 Plastic receptacle | 13 | 4.5 | Final design 67 |
| 3.3.2.10 Spigot | 14 | 4.5.1 | Improved filter: configuration options 68 |
| 3.3.2.11 Filtron ceramic filter element | 14 | 4.5.2 | Stacked components and packaged filters 69 |
| 3.3.3 The Filtron filter: Packaging | 15 | 4.5.3 | Receptacle 71 |
| 3.3.4 Flow-rate testing of Filtron filters | 16 | 4.5.4 | Lid 72 |
| 3.3.4.1 Process of flow-rate testing | 16 | 4.5.5 | Stand 73 |
| 3.3.4.2 Results of flow-rate testing | 16 | 4.5.6 | Hanging handle 74 |
| | | 4.6 | Prototypes 75 |
| | | 4.6.1 | Full-size working prototype production 76 |
| | | 4.6.2 | Half-size rapid prototype production 76 |
| | | 4.7 | Synopsis 77 |

CHAPTER 5: SUMMARY, RECOMMENDATIONS AND PROPOSALS FOR FURTHER RESEARCH 78

| | | |
|-------|---|----|
| 5.1 | Summary of the improved filter design | 78 |
| 5.2 | Summary of the benefits of the Filtron filter carried through into improved filter design | 78 |
| 5.3 | Cost of tooling and manufacturing of improved filter components | 78 |
| 5.3.1 | Conclusions of costings | 78 |
| 5.4 | Why the improved filter is better than the Filtron filter | 79 |
| 5.5 | Recommendations and proposals for further research | 79 |
| 5.6 | Relevance to institutional and national objectives | 79 |
| 5.6.1 | Relevance to national objectives | 79 |
| 5.6.2 | Relevance to the University of Johannesburg – community engagement | 80 |
| 5.6.3 | Relevance to the University of Johannesburg – inter-university collaborations | 80 |
| 5.6.4 | Relevance to the Faculty of Art, Design and Architecture | 80 |
| 5.6.5 | Relevance to the Industrial Design Department | 80 |
| 5.7 | Conclusions to the study | 80 |

BIBLIOGRAPHY / SOURCE LIST 81

FURTHER READING 82

ANNEXURES 84

| LIST OF FIGURES | PAGE |
|---|------|
| Figure 1.1: Vhembe region: Large plastic drum. Water containers easily collect insects and dust if left uncovered, introducing contaminants | 1 |
| Figure 1.2: Vhembe region: Ceramic water storage vessel with insects floating on surface of the water | 1 |
| Figure 1.3: Vhembe region: Dog sitting amongst food preparation and water storage equipment. Dogs can easily lick openings to water containers and food preparation equipment | 1 |
| Figure 1.4: Researched villages in relation to South Africa (Google Maps, 2008) | 2 |
| Figure 3.1: The design process simplified (Newman, 2008) | 7 |
| Figure 3.2: Application of methodologies to this project | 7 |
| Figure 3.3: The Potpaz filter upon implementation | 8 |
| Figure 3.4: Assembled Filtron filter | 10 |

| | |
|--|----|
| Figure 3.5: Filter components before assembly | 10 |
| Figure 3.6: Spigot and receptacle. Note the hole in the receptacle into which the spigot will be assembled. The piece of plastic from the hole lies next to the spigot | 11 |
| Figure 3.7: Spigot attached to receptacle | 11 |
| Figure 3.8: The filter retaining ring is placed onto receptacle | 11 |
| Figure 3.9: The filter element is lifted by the rim | 11 |
| Figure 3.10: The filter element is lowered into the retaining ring | 11 |
| Figure 3.11: The filter element rests on the retaining ring | 12 |
| Figure 3.12: The filter element filled with water | 12 |
| Figure 3.13: Operation of the Filtron filter | 12 |
| Figure 3.14: Covering lid and retaining ring | 13 |
| Figure 3.15: Moulding of covering lid/retaining ring | 13 |
| Figure 3.16: Cutting lid moulding to create retaining ring | 13 |
| Figure 3.17: Plastic receptacle | 14 |
| Figure 3.18: Injection moulding receptacle | 14 |
| Figure 3.19: Spigot, including locking nut, and silicone washer | 14 |
| Figure 3.20: Filtron ceramic filter element | 15 |
| Figure 3.21: Filter packed with shredded cardboard | 15 |
| Figure 3.22: Boxes containing filters stacked to a height of five boxes | 15 |
| Figure 3.23: Unpacking of Potpaz filter components | 15 |
| Figure 3.24: Damaged filter element box | 16 |
| Figure 3.25: Filters were filled with water, and water level constantly monitored | 16 |
| Figure 3.26: Measuring of filtered water | 16 |
| Figure 3.27: Top view of filter rim showing the filter number | 16 |
| Figure 3.28: Flow-rate testing results compared to Filtron leaflet | 17 |
| Figure 3.29: Flow-rate testing results compared to Potters For Peace website | 17 |
| Figure 3.30: Flow-Rate testing results compared to Lantagnes report | 18 |
| Figure 3.31: Completed self-assessment form, form #694 | 19 |
| Figure 3.32: GPS navigation utilised for locating households | 20 |
| Figure 3.33: A Venda-speaking interviewer conducting an interview with a Filtron user | 20 |
| Figure 3.34: Observation of stocking areas within rural spaza shops | 21 |
| Figure 3.35: Potters from a community potting project, Limpopo province | 21 |
| Figure 3.36: In which room is the Filtron filter kept? | 23 |
| Figure 3.37: Filter in main room | 23 |
| Figure 3.38: Filter in lounge | 23 |
| Figure 3.39: On what surface is the Filtron filter placed? | 24 |
| Figure 3.40: A loosely stacked stock brick pedestal | 24 |
| Figure 3.41: Makeshift pedestal- stock bricks wrapped in newspaper | 24 |
| Figure 3.42: Does this surface form part of the surrounding area or has it been specifically constructed for the filter? | 25 |
| Figure 3.43: Filter on existing surface | 25 |
| Figure 3.44: Filter stand constructed from a plastic crate and wooden plank | 25 |
| Figure 3.45: How does the user retrieve water from the filter? | 26 |
| Figure 3.46: Users retrieving water from filters | 26 |

| | | | |
|---|----|--|----|
| Figure 3.47: How high is the placement surface above the floor? | 27 | Figure 3.89: The loose fitting covering lid is easy to operate | 41 |
| Figure 3.48: Filter placed on work surface | 27 | Figure 3.90: Do you experience any problems or irritations when cleaning the ceramic filter? | 42 |
| Figure 3.49: Filter placed on cabinet | 27 | Figure 3.91: Does the filter's tap leak water? | 42 |
| Figure 3.50: If you could have the Filtron filter placed at any height, what do you think would be ideal? | 28 | Figure 3.92: Leaking spigot problem corrected by tightening the spigot retaining nut | 42 |
| Figure 3.51: User indicating preferred height 1 | 28 | Figure 3.93: Does the filter's tap supply water fast enough? | 43 |
| Figure 3.52: User indicating preferred height 2 | 28 | Figure 3.94: Does the filter provide sufficient water for everyone in your family? | 43 |
| Figure 3.53: Has the filter ever been knocked over? | 29 | Figure 3.95: Ninety eight percent of the households stated that the filter provides sufficient water | 43 |
| Figure 3.54: Filter on an inverted bucket | 30 | Figure 3.96: Does the Filtron filter look clean? | 44 |
| Figure 3.55: Have you experienced any stability problems? | 30 | Figure 3.97: Varying level of filter cleanliness: spigot | 44 |
| Figure 3.56: Filter placed on an unstable surface | 31 | Figure 3.98: Varying level of filter cleanliness: covering lid | 44 |
| Figure 3.57: How do you lift the lid? | 31 | Figure 3.99: Dirt traps | 45 |
| Figure 3.58: Incorporated lifting handle | 32 | Figure 3.100: Dust/dirt trap on the filter covering lid | 45 |
| Figure 3.59: Do you use a specific container or not? | 32 | Figure 3.101: Plastic products on fridges are similarly sized to the Filtron filter | 46 |
| Figure 3.60: Different containers used for retrieving water from filter | 32 | Figure 3.102: Small spaza shop stocks no products similarly sized to Filtron filter | 46 |
| Figure 3.61: How do you hold the container and open the tap? | 33 | Figure 3.103: Spaza shop has ample room to stock filter components | 47 |
| Figure 3.62: Container placed on the floor and spigot locked to an open position | 33 | Figure 3.104: Filter components could possibly stack on a top shelf | 47 |
| Figure 3.63: Container held underneath spigot and tap operated by user | 33 | Figure 3.105: Potters in the Vhembe region preparing clay before shaping it into various products | 48 |
| Figure 3.64: Are any parts of the filter broken or damaged? If so, what parts? | 34 | Figure 3.106: Low level of filtered water in the receptacle | 48 |
| Figure 3.65: Slightly damaged filter element | 34 | Figure 3.107: Water retrieval from the receptacle | 49 |
| Figure 3.66: Broken filter element | 34 | Figure 3.108: Possible graphic indicating "full" mark | 49 |
| Figure 3.67: Where is the Filtron filter located in relation to stored water? | 35 | Figure 3.109: Mistaken lifting handle proved un-ergonomic | 49 |
| Figure 3.68: Unfiltered water stored directly next to Filtron filter | 35 | Figure 3.110: The spigot has two positions: locked flow and temporary flow | 50 |
| Figure 3.69: Unfiltered water stored in the same room as the Filtron filter | 35 | Figure 3.111: Filter user sitting on floor, manually keeping the spigot in temporary flow position | 50 |
| Figure 3.70: Have any alterations been made to the Filtron filter? | 36 | Figure 4.1: Dowel and 16 mm Supawood ready to assemble | 64 |
| Figure 3.71: Spigot repair using part of a plastic bag | 36 | Figure 4.2: Wooden support platform constructed | 64 |
| Figure 3.72: Filter element used as a storage vessel for sundry household items | 36 | Figure 4.3: Masonite spacer | 65 |
| Figure 3.73: Cardboard KIC packaging utilised by a rural household as a storage solution for multiple household items | 37 | Figure 4.4: Support attached to the receptacle | 65 |
| Figure 3.74: Plastic container no longer used for storing water | 37 | Figure 4.5: Developed CAD model and stability prototype made from the CAD model | 65 |
| Figure 3.75: Is there a difference in the taste of the filtered water? | 37 | Figure 4.6: Construction of simplified covering lid | 65 |
| Figure 3.76: Filter user sips filtered water from a designated drinking container | 38 | Figure 4.7: Spreading the legs increases the stability footprint | 66 |
| Figure 3.77: Do you like the taste of filtered water? | 38 | Figure 4.8: Legs located around the receptacle rim | 66 |
| Figure 3.78: How many times do you fill the filter per day? | 38 | Figure 4.9: Improved filter | 67 |
| Figure 3.79: How do you fill the ceramic filter? | 39 | Figure 4.10: Full-size working prototype | 75 |
| Figure 3.80: Twenty five litre containers used for storing unfiltered water | 39 | Figure 4.11: Half-size rapid prototype model | 75 |
| Figure 3.81: Users decant water from a blue plastic barrel into the Filtron filter, using a plastic jug | 39 | Figure 4.12: Full-size working model production | 76 |
| Figure 3.82: Is the Filtron filter in operation? | 40 | Figure 4.13: Finished parts took a total of 95 hours to 'grow' | 77 |
| Figure 3.83: Neglected filter receptacle containing water and insects | 40 | Figure 4.14: Components sprayed to portray intended colours better | 77 |
| Figure 3.84: Filter receptacle used for flour storage | 40 | | |
| Figure 3.85: Are there any insects present underneath the lid? | 40 | | |
| Figure 3.86: Condensation under the covering lid attracts insects | 41 | | |
| Figure 3.87: Insects on the filter retaining ring | 41 | | |
| Figure 3.88: Do you experience any problems when filling the filter? | 41 | | |

LIST OF TABLES

| | PAGE |
|---|-------------|
| Table 1: Summary of flow-rates according to three different sources | 18 |
| Table 2: Results from self-assessment form data | 19 |
| Table 3: Breakdown of field research interviews and observations | 21 |
| Table 4: Dimensions of available spaza shop storage space | 47 |

LIST OF ANNEXURES

| | PAGE |
|--|-------------|
| Annexure 1: Diagram describing the point-of-use project | 84 |
| Annexure 2: Permission to use intellectual property on the Potpaz water purifier | 84 |
| Annexure 3: Filtron leaflet, received with imported Filtron filter | 85 |
| Annexure 4: Cost breakdown of imported filters | 86 |
| Annexure 5: Requisition form: Purchasing cost, and importing cost of Filtron filters | 86 |
| Annexure 6: Instruction leaflet 1, designed by M. Bolton. English version | 87 |
| Annexure 7: Instruction leaflet 1, designed by M. Bolton. Translated Venda version | 87 |
| Annexure 8: Instruction leaflet 2, designed by M. Bolton. English version | 88 |
| Annexure 9: Instruction leaflet 2, designed by M. Bolton. Translated Venda version | 88 |
| Annexure 10: Self-assessment form, designed by M. Bolton. English version | 89 |
| Annexure 11: Self-assessment form, designed by M. Bolton. Translated Venda version | 89 |
| Annexure 12: English version of informed consent form for use during field visits | 90 |
| Annexure 13: Translated Venda version of informed consent form for use during field visits | 91 |
| Annexure 14: English version of questionnaire for use during the conducting of interview schedules | 92 |
| Annexure 15: Translated Venda version of questionnaire used during the conducting of interview schedules | 92 |
| Annexure 16: Additional questions asked in conjunction with the Interview Schedule | 93 |
| Annexure 17: Personal observation sheet completed at each household visited during the conducting of field research | 93 |
| Annexure 18: Personal observation sheet completed at each spaza shop visited during the conducting of field research | 94 |
| Annexure 19: Variations of the Potpaz ceramic filter (PFP, 2006f:4) | 94 |
| Annexure 20: Manufacture of the Potpaz ceramic filter. | 95 |
| Annexure 21: Press construction diagrams | 96 |

| | |
|---|----|
| Annexure 22: Import costs per container from China | 98 |
| Annexure 23: Costing calculations of filters. Improved, and Filtron filters | 99 |

CHAPTER 1: CONTEXT, PROBLEM STATEMENT AND RESEARCH OBJECTIVES

1.1 Context

According to the Department of Water Affairs and Forestry (DWAF), whose responsibility it is to ensure that South African citizens are provided with efficient, cost-effective and sustainable water services, 74% of South African households have been supplied with safe water (DWAF, 2007). The irony is that although safe water supplies have been introduced into rural areas in various forms, such as communal taps and borehole pumps, a constant problem is created when the water is consumed at point-of-use¹, due to the fact that it's health-related microbial quality has deteriorated to the point where it is "unsafe" to drink (Gundry, Wright, Conroy, du Preez, Genthe, Moyo, Mutisi, Ndamba, Potgieter, 2006:7). This contamination occurs in the plastic vessels used to transport water from communal taps, and store the water in the household cooking area until used (Gundry et al, 2006:2). It is caused by the introduction of microbial water contaminants via various sources including people, insects (fig. 1.1 & 1.2) and animals (fig. 1.3).



Fig. 1.1 Vhembe region: Large plastic drum. Water containers easily collect insects and dust if left uncovered, introducing contaminants



Fig. 1.2 Vhembe region: Ceramic water storage vessel with insects floating on surface of the water



Fig. 1.3 Vhembe region: Dog sitting amongst food preparation and water storage equipment. Dogs can easily lick openings to water containers and food preparation equipment

In terms of Article 27 (1, b) of the Constitution (1996), everyone has the right to access sufficient food and water. This water should be of a potable² quality and must not cause disease in the consumers. *"The magnitude of the task of providing people without sustainable access to improved water supply with the ultimate option, piped water in the near future has initiated investigations into alternative technologies. Point-of-use interventions are fast becoming the preferred method for providing improved water quality"* (Du Preez et al, 2008: 1 &

¹ Point-of-use refers to the point where, in most rural cooking/food preparation areas, stored water is used for cooking or consumed for drinking. This is not necessarily where water is collected, as many rural households do not have tap water in their homes.

² Potable: fit for human consumption.

2). One of these low-cost interventions is the Potpaz³ filter, designed by Potters For Peace in the USA (2006). This filter was chosen to be used in a collaborative research project undertaken in the Vhembe region, Limpopo province of South Africa. The Potpaz filter has already proven to be effective in reducing the number of microbes in contaminated water to levels where water is being treated on a microbiological scale in a laboratory environment⁴. However, its assembled design seems to be far from optimal in terms of usability as a manufactured product. This is evident from the field testing conducted in several previous studies (Lantagne, 2001b:55). The objective of this MTech Dissertation was to observe how the existing Potpaz filter could be improved as a product and to develop a design for it to be optimal for rural use.

1.2 Background

In June 2006, Professor Paul Jagals approached Mr Angus Campbell, Lecturer in the Department of Industrial Design at the University of Johannesburg, to discuss the opportunity for an MTech Industrial Design student to be part of a health related water quality assessment project focussing on point-of-use. This project was a collaborative project between the University of Venda (UniVen) and the University of Johannesburg (UJ). It was funded by the Water Research Commission through UniVen, with research being conducted in approximately 25 rural villages in the Vhembe district (fig. 1.4). This MTech Dissertation is an output from this research activity.

The point-of-use⁵ project aimed to investigate whether a sole intervention that improves the health-related quality of water would measurably improve the health of the consumers of the water. The chosen intervention, the Potpaz filter, has been proven to be effective in other parts of the world. The point-of-use project research was conducted by sourcing, purchasing and importing 400 Potpaz filters from Ghana. Thereafter, the filters were implemented in households within the rural areas. These households use of the filters provided the data that was gathered.

³ The Potpaz home water treatment device is a low-cost gravity fed colloidal silver impregnated ceramic water filter able to clean sufficient water for one household. It is also known as the Potters For Peace ceramic water filter (PFP, 2006c).

⁴ Van Halem, 2006: Ceramic silver impregnated pot filters for household drinking water treatment in developing countries; Lantagne, Investigation of the Potters for Peace Colloidal Silver Impregnated Ceramic Filter, Report 1; Fahlin, C.J., 2003: Hydraulic properties investigation of the Potters for Peace Colloidal Silver Impregnated, Ceramic Filter.

⁵ Point-of-use project refers to the collaborative research project between UniVen and UJ.

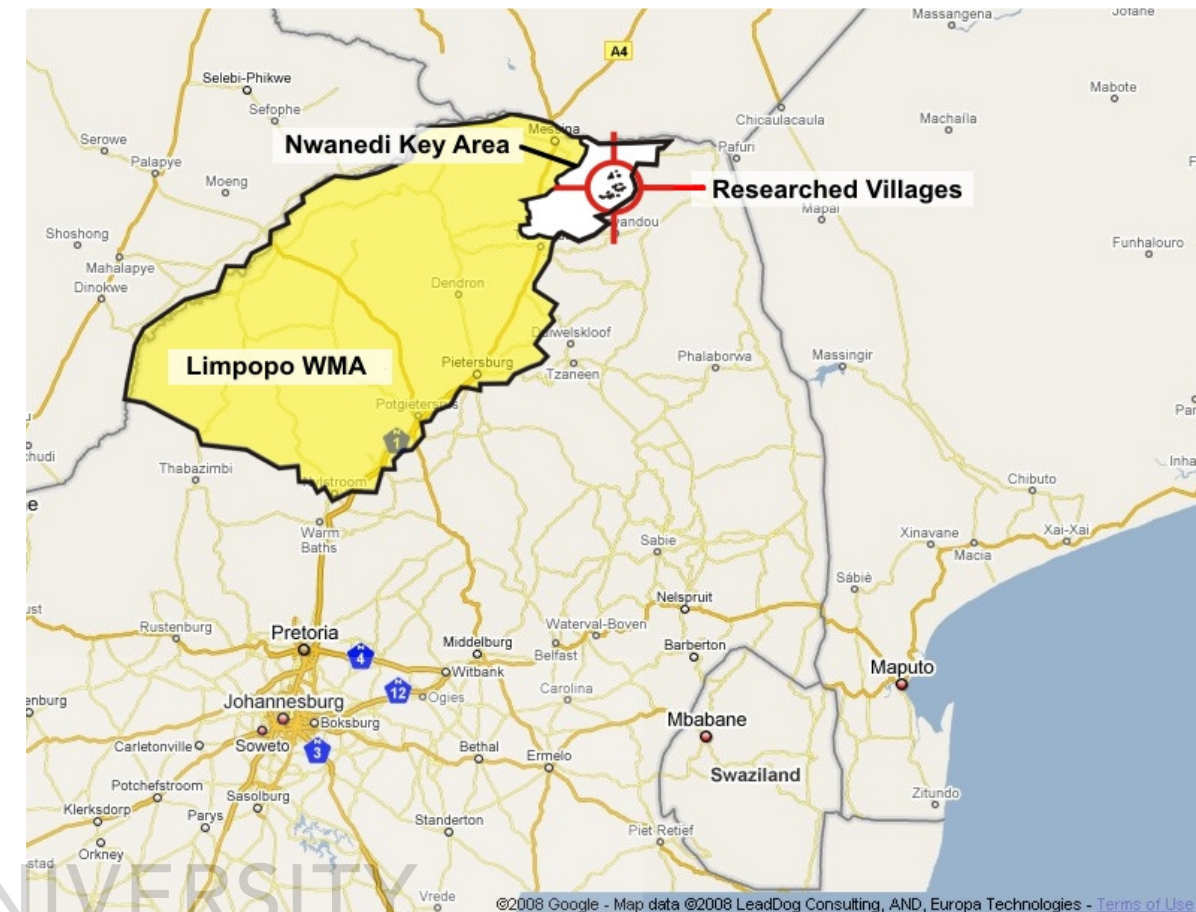


Fig. 1.4 Researched village locations in South Africa (Google Maps, 2008)

The Department of Industrial Design worked in collaboration with other sections of speciality in the point-of-use project. Each of these brought their area of specialisation into the overall research of the filter intervention. The various sections of the point-of-use project are summarised below, and are portrayed graphically in annexure 1.

- **Microbiology:** Water quality assessment at point-of-collection, point-of-storage, and point-of-use. Water samples were collected for analysis from community water collection points, water storage containers in households and filtered water in Potpaz filter receptacles regularly. The samples were analysed in a field laboratory or at UniVen.
- **Epidemiology:** The epidemiology of waterborne disease, investigated through the observing of incidences of diarrhoea at a household level by collecting diarrhoea occurrence forms, and other health data from clinics.
- **Sociology:** The sociology of water management in the home, observed by means of interviews and community focus group meetings. Household interviews provided data

specific to that household, whereas community focus group meetings provided broader opinions of the rural community.

- **Industrial Design:** Concerned with the assessment of the Potpaz filter as a product intended to be as usable for the intended rural households as possible. This part of the research included:
 - The sourcing of existing manufacturers of Potpaz home water treatment devices.
 - The assessment of the filter with regard to transport, packaging and damage assessment after shipping.
 - The design of various instructional leaflets that were supplied to households together with the Potpaz filters (annexures 6-9).
 - The designing of a data collection form to assess if correct filter maintenance is followed (annexures 10 & 11).
 - Flow-rate testing (quality control) and re-packaging of ceramic filter elements.
 - The gathering of data from the intervention households that received filters. This data was used in improving the design of the Potpaz filter.
 - Conduct field visits, researching the use of the Potpaz filters within the rural households. This data provides insight into understanding the use of the filters, and the needs and requirements of the intended users.

By working alongside the various sections of the point-of-use project, it made available knowledge specific to the intended user, beneficial in the designing of an improved water filter. This knowledge would otherwise have been very difficult to obtain.

1.3 Research objectives

My involvement as an industrial designer in this point-of-use project focused on the Potpaz filter and its effectiveness as a product. The objectives of this MTech project focuses on

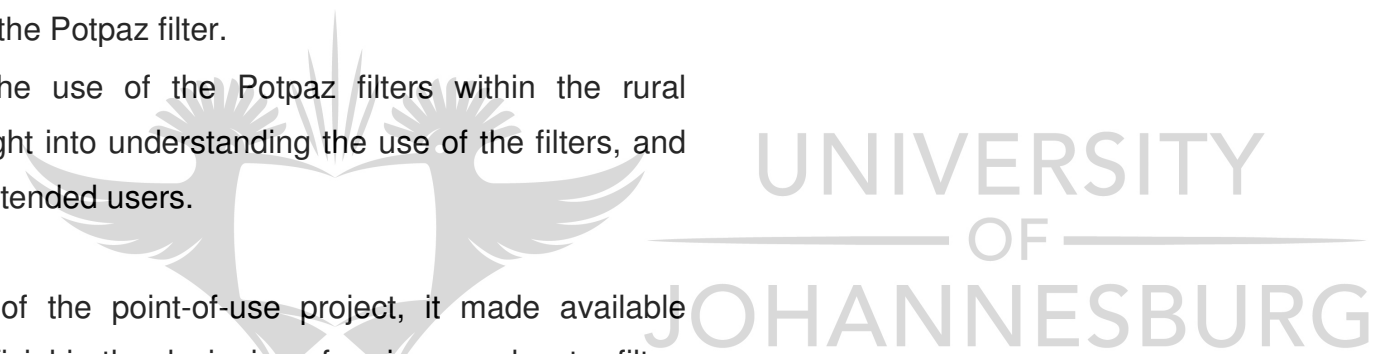
1. an understanding of whether the Potpaz filter functions optimally or not in the rural setting with regards to usability and ergonomics, and if not,
2. develop a new design of a water filter unit as a solution for suitable rural household use.

1.4 Problem statement

While the Potpaz filter was shown in other areas to be effective, it was not clear whether or not it would be effective within rural areas of South Africa in terms of its suitability for the rural

setting in which was to be implemented. There is evidence that the water consumed at point-of-use in rural areas is not always of a potable quality due to possible contamination between collection and consumption. It has been proven in previously conducted research that the Potpaz filter is able to improve the microbial quality of the water. However, research regarding the testing and development of an existing product has not been conducted in rural areas of South Africa.

In the following chapter, several studies will be presented regarding research of water filters in rural households, and investigations conducted specific to the Potpaz home water treatment device.



CHAPTER 2: LITERATURE REVIEW

2.1 Introduction: The point-of-use project

The point-of-use project was the first of its kind to be conducted in South Africa, utilising the Potpaz filter as a home water treatment device. There has however been a range of tests across the rest of the world⁶. Several studies have been undertaken on other types of water filters. Below I will explore the ones most relevant in the context of this study, and thereafter I will focus specifically on a selection of the most relevant Potpaz filter studies.

A range of water treatment methods are available that can improve the quality of drinking water for human consumption. The treatment varies in method and scale, based on water output volume. Large-scale treatment methods are treatment plants suited to supply cities and towns. Medium-scale treatment methods supply a sufficient amount of potable water for a community or household. Small-scale treatment methods are portable home and personal water treatment units used for small volumes of water from varied sources, such as for households in rural areas as well as for hiking or camping. All water treatment methods utilise one or more of the following water treatment steps: straining, storage, settlement, solar disinfection, chemical disinfection, boiling, coagulation, flocculation, filtration, and solar distillation (Shaw, 1999:101-108). The Potpaz home water treatment device utilises a treatment combination of filtration (ceramic) and chemical disinfection (colloidal silver).

For the remainder of this chapter, I will describe several studies conducted globally regarding effective home water treatment methods. I will then describe several detailed laboratory and field studies conducted with the Potpaz home water treatment device.

2.2 Studies of water filters in rural households

In an editorial entitled *“Household water management: refining the dominant paradigm”* Clasen and Cairncross (2004) explore a number of interventions to treat water, such as the physical removal of pathogens, chemical treatment, and heat as well as ultra violet radiation. They highlight the importance of clean water for user’s standard of living: *“Health authorities generally accept that safe water plays an important role in preventing outbreaks of diarrhoeal disease”*(Clasen and Cairncross, 2004:187).

⁶ A detailed list of previously conducted studies can be viewed on the Potters for Peace website. (PFP, 2006g). These include investigations undertaken in Cambodia, Nicaragua and Holland just to name a few. These studies focus on filter capabilities and effectiveness, as well as field testing of the filter units.

The most recent research conducted in terms of water treatment interventions at point-of-use was undertaken in the same rural area as this point-of-use project as well as in Zimbabwe (Du Preez et al, 2008). In this study, households were supplied with a small scale gravity-fed ceramic water filter (British Berkefeld Big Berkey filter⁷), and the effectiveness of the filter documented. This was done by recording diarrhoea cases in 61 intervention and 54 non-intervention households and comparing the data. “The presence of home filtration had a significant effect on the incidence rates of all forms of diarrhoea, reducing incidence of both bloody and non-bloody diarrhoea by 80%” (Du Preez et al, 2008: 6). It is therefore evident that by use of gravity-fed ceramic water filters, the health of the consumers is increased substantially. Although the Big Berkey filter is able to produce water free from bacteria and parasites immediately and consequently reduce diarrhoea, its biggest disadvantage is its cost, with each filter used in this study costing R655.00 (priced on 2008/08/19). Research conducted with the Potpaz home water treatment device had showed the cost thereof totalling approximately R100 per filter (priced on 2007/08/07), much less costly than the British Berkefeld Big Berkey filter.

2.3 Studies of the Potpaz filter

Research conducted with the Potpaz home water treatment device has mainly been undertaken in a laboratory environment. This was linked to the efficiency of the ceramic filter with regard to flow-rate and how well microbes are removed from the water⁸. To date, no studies have evaluated the Potpaz filter in terms of its ability to suit its intended users, and the development of a solution to be more suited to the intended users. This is the key component of this research project and the involvement of Industrial Design. In the case of this project, the intended users are the people living within the Venda area.

The thesis: *“Hydraulic properties investigation of the potters for peace colloidal silver impregnated, ceramic filter”* (Fahlin, 2003), contains in-depth testing regarding the hydraulic conductivity (how water travels through media, in this instance, the ceramic filter) and tortuosity (the twisting and winding path of fluid travelling through the media) of the filter. This research focuses only on the scientific functionality of the filter and how effectively it inactivates

⁷ Gravity-fed ceramic water filter utilising replicable ceramic candle filter elements (Doulton filters, 2007).

⁸ Van Halem, 2006: Ceramic silver impregnated pot filters for household drinking water treatment in developing countries; Lantagne, Investigation of the Potters for Peace Colloidal Silver Impregnated Ceramic Filter, Report 1; Fahlin, C.J, 2003: Hydraulic properties investigation of the Potters for Peace Colloidal Silver Impregnated, Ceramic Filter.

pathogens. It does propose an improvement: *“The only recommendation for Potters for Peace is to try new ways to fully utilize the entire path of water flow through the filter for contact with inactivating silver”* (Fahlin, 2003:9).

“Investigation of the potters for peace colloidal silver impregnated ceramic filter, report 1: intrinsic effectiveness”, and “...report 2: Field investigations” (Lantagne, 2001a&b) pertain to extensive scientific and field testing of the Potpaz home water treatment device. Several laboratory tests were conducted to observe the effectiveness of several aspects of the Potpaz ceramic filter, including the flow-rate, expected lifetime per ceramic filter, concentration of colloidal silver in treated water, and the effects of the consumption of the colloidal silver: *“...based on these results, it is concluded that the PFP filter effectively removes and inactivates bacteria and bacterial indicators of disease-causing organisms”* (Alethia Environmental, 2007, report 1:1). After the field investigations, the following recommendations were made:

- *Partner NGOs⁹ should be educated on factors that affect the success and failure of the filter. They should also be encouraged to regularly follow-up with and provide education to the families with the filter. A manual providing information and projects tips should be developed and distributed to NGOs with a filter program.*
- *A cleaning kit that can be used to scrub the filter to regenerate the flow rate and to disinfect the receptacle to prevent recontamination should be developed and sold with each filter. In addition, families need to be educated about correct filter cleaning methods.*
- *Plastic receptacles should be encouraged over ceramic [due to the fact that the porosity of the ceramic allows a biofilm to form more easily than on a plastic surface]”* (Alethia Environmental, 2007, report 2:1).

2.4 Advantages and disadvantages of the Potpaz filter

Although the Potpaz filter has been proven to be microbiologically effective, there are several disadvantages of the ceramic filter element and the complete assembled filter. Below is an interpretation of the data found in the Potters For Peace follow-up manual (PFP, 2006f). It contains a summary of advantages and disadvantages of the assembled filter unit, as well as the ceramic filter element. The advantages of the **complete filter unit** include:

- Plastic receptacles are strong, lightweight and easy to transport.

- If receptacles are maintained properly, filtered water can meet various standards¹⁰.
- Assembled filter unit is low-cost.
- Assembled filter has been proven effective in every study conducted.
- Assembled filter is easy to transport and assemble.

Disadvantages of the **complete filter unit**:

- If parts break, replacement components are often unavailable.
- As there is no residual microbicidal action in filtered water, both ceramic and plastic receptacles are susceptible to contamination and must therefore be maintained correctly.

Advantages of the **ceramic filter element**:

- Laboratory testing of the filter element is effective for removing over 99% of bacteria, protozoa and worms and turbidity¹¹.
- Filters can be manufactured by using existing technology and materials available in the country.
- Colloidal silver can be manufactured locally; all that is required, is the purchase and importing of a colloidal silver manufacturing machine.
- Replacement filter elements can be sold at a low cost.
- Filters can be maintained successfully by using simple tools (e.g. scrubbing brush)

Disadvantages of the **ceramic filter element**:

- From laboratory testing, the filter element is not effective in removing viruses, metals and pesticides.
- The filter element is relatively fragile and can break if dropped or lifted incorrectly.
- Once pores are clogged the flow-rate decreases (PFP, 2006f: 4).

2.5 Synopsis

Several studies have been conducted that have demonstrated that the Potpaz filter is an effective water treatment device in terms of microbial treatment. Specific studies however, have not been on conducted on its effectiveness in rural areas of South Africa especially on its practical use. For this to be undertaken a research methodology considering the user needs to be investigated. The following chapter describes the methodological approach followed in developing an improved water filter unit. Research results are then presented, and the gathered data is analysed.

⁹Non Governmental Organisations

¹⁰ World Health Organisation (WHO) and United States Environmental Protection Agency (USEPA) standards.

¹¹ Water is unclear due to agitated sediment or suspended particles.

CHAPTER 3: RESEARCH METHODOLOGY, DATA COLLECTION, RESEARCH RESULTS AND DATA ANALYSIS

3.1 Introduction

Before designing a product, and in the case of this project, development the design of a product, a list of design requirements needed to be formulated. These design requirements are criteria the product should satisfy in order to fulfil its intended function successfully. The methodological approach conducted to construct this list of design requirements is described below. Thereafter, the steps of the design process are described in detail.

3.2 Research methodology

As a primary researcher and designer in this project, I come from a significantly different background to the rural communities for whom I was designing. This made it difficult for me to understand the circumstances, requirements and preferences of the users for whom the design would be developed, unless I was able to gain an understanding of, and insight into their lifestyle. This was attainable by actively communicating and engaging with the rural communities taking part in the point-of-use project. I formed part of the intervention team which conducted the research within the communities. The value of me, the designer, experiencing the data generation is beneficial as described by Green & Jordan in *Human factors in Product Design*:

... the data in design terms is less likely to be a corrupt process when the designer is using self-generated data, and the efficiency with which the data is incorporated into the design process is enhanced immeasurably if the designer is intimately involved. (1999, 13)

By including myself in the data gathering and generation process, as well as gathering useful data from the intended users, I had the opportunity to understand the needs and preferences of the intended rural users regarding the use of the device by interviewing the users, and observing the environment where the filter units were kept. Their input was invaluable to successfully observe where the existing filter functioned effectively, as well as in the development of an improved water filter, centred around their needs, requirements and preferences. From an industrial design perspective, I possess technical knowledge and capabilities with regard to product development. The rural communities however, do not have these skills, although they are the intended users of the product. For this reason the research

approach I followed was User Centred Design, placing the user at the centre of the design process. In his MTech Industrial Design dissertation, Fowler states that...

An industrial design methodology that does not acknowledge the values of potential product users is unlikely to be able to address accurately the needs of these users, and widespread product acceptance is then unlikely to be achieved. (Fowler, 2005:23).

User Centred Design, as a design methodology originated in Donald Norman's research laboratory at the University of California San Diego (UCSD) in the 1980s (Abrams, Maloney-Krichmar, Preece, 2004).

Norman's work stressed the need to fully explore the needs and desires of the users and the intended uses of the product. The need to involve actual users, often in the environment in which they would use the product being designed, was a natural evolution in the field of user-centered design. Users became a central part of the development process. Their involvement lead to more effective, efficient and safer products and contributed to the acceptance and success of products. (Abrams, et al, 2004).

Placing the users at the centre and including them in the research part of the design process allows for a product to be designed that suits the user, reducing the chance of the designer's pre-conceptions regarding the user influencing the design. In his book *The Design of Everyday Things*, Norman writes that well-designed objects are easy to interpret and understand, as they contain visible clues to their operation. This is not true for poorly designed objects, as they can be difficult and frustrating to use due to the fact that they provide no clues (Norman, 1990: 2). It is therefore important for the designer to have an understanding of what the user would consider easy to use, and to design in terms of such constraints. The best way to do this is to include the user's feedback with regard to interaction with a similar product or development models to inform the design process of the improved product. For this project, the users supplied data during the research stage of the project. This stage of the design process has been indicated using pink in figure 3.1.

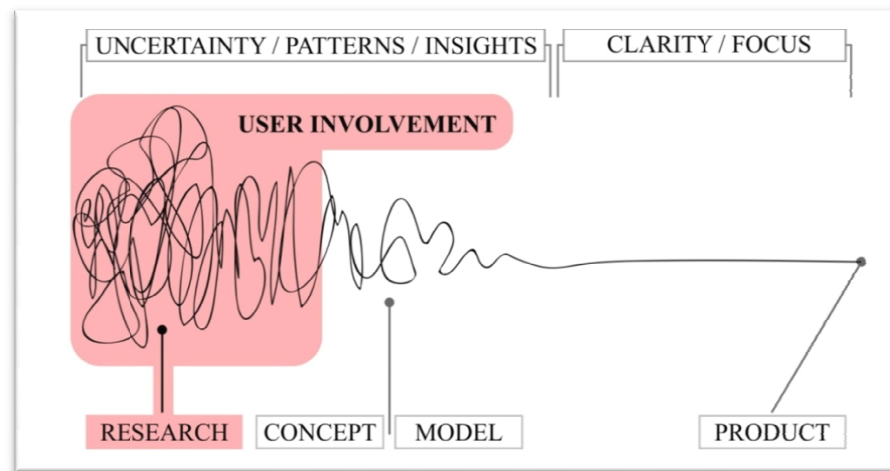


Fig. 3.1 The design process simplified (Newman, 2008)

The diagram displays a messy squiggle, which slowly narrows down to a straight line. This graphically portrays the design process, progressing from research through to concepts, culminating in a final product. The final designed product clearly relies on the research to inform the design. This is explained in the *Handbook of Action Research*, where Peter Reason and Hilary Bradbury state that:

...action research is a participatory, democratic process concerned with developing practical knowing in the pursuit of worthwhile human processes, grounded in a participatory worldview which we believe is emerging at this historic moment. It seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people, and more generally the flourishing of individual persons and their communities (2001:1).

Research methodology that relies extensively on the participation of the users of the product is called action research. My project methods met many of the criteria of the action research methodology. However, it cannot be solely classified as this type of methodology. It is generally understood that action research methodology proposes that the participants, in this case the community, “...identify a problem, do something to resolve it, see how successful their efforts were, and if not satisfied, try again” (O’Brien, 1998). In other words, the researcher is the facilitator, and the community conducts the research, from identifying problems through to developing solutions. This was not the case with this research project, since the communities for whom the water filter was to be developed did not initially understand the need for improved water quality, and did not attempt to provide a solution to the problem. It would be difficult for rural communities to undertake the re-design of the Potpaz home water treatment device due

to the skills required to undertake such a task. However, giving the community an opportunity to be involved and give feedback, allowed for the gap between the users of the product and my own pre-conceptions (as the designer) to be narrowed. A diagram was compiled to communicate the overall methodological approach to the design process better (fig. 3.2).

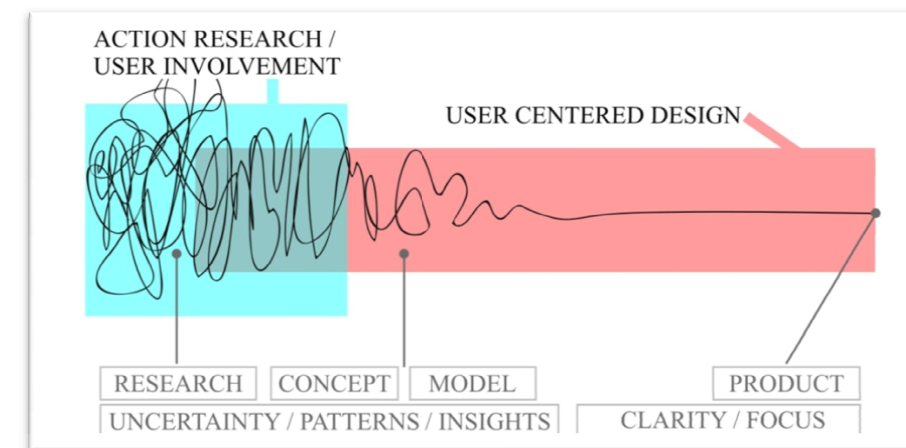


Fig. 3.2 Application of methodologies to this project.

As stated by Professor Prashant Kumar, the Head of the Design Programme and Professor in Mechanical Engineering at the Indian Institute of Technology, Kanpur...

The form of a product depends on many aspects such as functional, ergonomic, aesthetic, emotional, economical viability of materials and manufacturing processes, traditions of the likely users. It is now being realized that a designer should consider all aspects of a product starting from the conceptual stage (Kumar, 2005:1).

The inclusion of a User Centred Design process in the development of a product makes it possible to have a product ideally suited to the user as well as to the intended manufacturing processes. The form of the product can be designed to not only be suited for intended use, but to be easily packaged, transported, shipped, stocked in stores and retail at a cost affordable to the intended user. By studying several products designed around the user, the value of the combined methodology of action research and User-Centred Design becomes evident. Furthermore, as stated by Margolin, designers are obligated to evaluate their designed products in actual situations to test their effectiveness (2002, 28).

3.2.1 Products designed with assistance from the intended user

An example of a product that was designed by utilising the input from rural users in Brazil, a developing country similar to South Africa, was a solar lamp designed by the *Grupo de Desenho Industrial e Desenvolvimento Sustentável* (GDIDS). This group includes academics and students¹² from the *Universidade Federal de Campina Grande*, in Brazil. In their findings, they explain that a product can be designed successfully for a rural user by taking his/her needs into account (Thomas, 2006:62): *“Although users were not directly involved with the design of the lamp, their needs were taken into account when the specifications were drawn up, and again in user testing of the product. The designers were able to fulfil the needs of a poor market”* (Thomas; 2006:58-59).

The GDIDS work with the poorest of the local population and *“...understand that designers should discard their peculiar presumptions if they are really serious about improving the low-income populations’ situation”* (Thomas, 2006:56). The research group worked closely with the user group who proposed modifications and improvements. The users’ involvement in the design process revealed problems that would not have become evident without their participation (Thomas, 2006:56).

Similarly, by including the users in the improvement of the Potpaz filter, valuable data were gathered. These data provided insight into usage, one of the most important aspects to consider. The data received from intended users who had been using the filter for several months was therefore invaluable. Informed consent for the observation of the immediate areas where the Potpaz home water treatment device was kept, was requested from each participating household. Since the people had been utilising the existing Potpaz filter for a considerable time, they were accustomed to its use and able to highlight any areas of irritation and possible improvement. These data was gathered by means of personal interviews with filter users, assisted by Venda-speaking translators/field assistants from the point-of-use project. Further data regarding routine filter cleaning were captured in the form of self-assessment forms. The final source of data gathered from the households included photographs of the where the filters were kept in each household, allowing for future visual reference of the environment where each filter was kept, as well as to observe trends across all the households from different villages.

¹² From the university’s Product Design course.

3.3 Data collection

3.3.1 Background research

The Potpaz filter is a low-cost, low-tech, colloidal-silver enhanced gravity-fed ceramic home water treatment device for use in rural households whose water at point-of-use is contaminated (fig. 3.3). It supplies enough water for drinking and food preparation for one household and has been proven to effectively remove 99.99 percent of protozoa organisms by mechanical processes (Lantagne, Quick, Mintz, 2008:25). It is a product which has been developed and manufactured to improve the low-income populations’ quality of water, in turn bettering their health.



Fig. 3.3 The Potpaz filter upon implementation

3.3.2.1 History of the Potpaz filter

The Potpaz home water treatment device was originally designed by Dr. Fernando Mazariegos, a researcher from the Central American Industrial Research Institute in 1981. Mazariegos developed a water filter to be as affordable as possible and to be manufactured at community level, thus empowering the “poorest of the poor” to provide their own potable water (in Potters For Peace, 2006a). In 1998, Potters For Peace (PFP), a US-based non-profit organisation devoted to socially responsible development, began assisting in the worldwide production of the Potpaz home water treatment device.

Potters For Peace grants permission for copying the Potpaz filter design, provided that specific conditions are met (annexure 2, regarding the intellectual property on the Potpaz filter). The Potpaz home water treatment device was developed with input from South American countries, such as Guatemala and Ecuador and has been in existence for 26 years (since the first prototype). The exact water filter that was imported for use in the point-of-use project is branded the Filtron water filter, manufactured by Ceramica Tamakloe (2006), situated in Ghana (annexure 3 for Filtron leaflet). The Filtron water filter is Ceramica Tamakloe's version of the Potpaz home water treatment device. This device is manufactured by various companies across the world, who brand the filter under their unique brand name. These countries include: Cuba, El Salvador, Guatemala, Cambodia, Colombia, Nicaragua, Dominican Republic, Sri Lanka, West Darfur/Sudan, India, Indonesia, Kenya, Ghana, Tanzania, Yemen and Benin (PFP, 2006d).

3.3.2.2 The effectiveness of the Potpaz filter

The Potters For Peace ceramic filter element operates by filtering out impurities in water, due to the properties of the materials used in the manufacturing process. The filter's porous characteristics are determined by the particle size and amount of sawdust mixed into the clay during preparation. The sawdust burns away during the firing process and creates pores in the filter to allow water flow through the element: *"The pore size in the filter ranges from 0.6 to 3.0 microns. The PFP pore size goal is 1.0 micron, in order to remove E. coli without the need for a disinfectant. These results show that PFP is well within range of their 1.0-micron goal."* (Lantagne, 2001a:31):

Studies done by MIT, UNICEF, Univ. of Colorado and numerous other researchers have proven the filter's effectiveness at eliminating at least 99% of E. Coli, Coli form and Streptococcus organisms (PFP, 2006b).

It has been shown that the filter element is able to improve the health related microbial quality of the water by means of the action of filtration. Effectiveness of the filter element, with regards to disinfection, can be increased with the application of colloidal silver to the filter element.

3.3.2.3 Added effectiveness with the application of colloidal silver

Colloidal silver increases the effectiveness of the filter element by means of chemical action, as explained by Lantagne:

E. coli is removed in a number of filters without colloidal silver application because the pore size is small enough to capture the E. coli. In addition, a significant fraction of total coliform and fecal coliform [sic] are removed without the colloidal silver, although it is not 100 percent removal. Thus, the colloidal silver is necessary for complete removal/inactivation of bacteria (Lantagne, 2001a:71).

Colloidal silver is an effective antibacterial water treating agent in the form of tiny silver particles suspended in liquid. It is a disinfectant that prevents bacterial growth in the ceramic filter and assists in inactivating the bacteria in the filter (Lantagne et al, 2008:25). *"...colloidal silver is a stable solution of very small silver particles suspended in distilled water or proteins"* (Lantagne, 2001b: 25). It is applied to the Potpaz filter in the form of a painted-on solution, or by dipping (after the firing process) thereby allowing the solution to soak into the porous ceramic filter where it remains. As stated in the colloidal silver information sheet available on the Potters For Peace website, a study indicates that after 15 years in operation, the colloidal silver is still effective in the ceramic filter (PFP, 2006b). Colloidal silver is used as a safe and effective water treatment agent, in conjunction with various filtration and storage methods for both large and small water systems (PFP, 2006c):

Filters as old as 7 years were tested and found to still remove 100% of total and fecal coliform [sic], indicating that the lifespan of the colloidal silver is indefinite. However, the policy of reapplication every year that is recommended by PFP should not be abandoned without further testing, because it provides a [sic] important margin of safety (Alethia Environmental, 2007, Report 1:1).

Colloidal silver can be purchased in either powdered or liquid form and is applied to the filter. Alternatively, ordinary equipment can be used to make the colloidal silver: *"... a mixture of water and colloidal silver is prepared; 2 ml of colloidal silver at 3.2% is added to 250 ml of water. When the filter is dry, it is dipped into the solution"* (Van Halem, 2006: 3). This is a sustainable solution, since a colloidal silver producing machine can be purchased abroad and imported. Thereafter, the colloidal silver solution can be manufactured locally at the filter manufacturing facility. An example of a colloidal silver manufacturing machine is the *Colloid Master Model 777 Universal*, produced by the company *Synergenesis Inc.* in Minnesota,

costing \$ 319.00 (28/09/2008) for the machine and all the necessary equipment for on-site manufacturing of colloidal silver (Wishgranted, 2008). Thereafter the only requirement is to purchase the consumable silver rods from local silver suppliers at a price of R6,40 per gram (excluding vat) (Metal Concentrators, 21/10/2008).

When the colloidal silver is applied to the filter, its effectiveness relies extensively on the flow-rate of the filter. The directions for disinfecting drinking water by using the colloidal silver are to add one drop of the solution to two litres of water and then wait 20 minutes. It is then safe to consume the water. This determines that two litres of water should have a contact time of a minimum of 20 minutes with the colloidal silver applied to the filter element (Lantagne, 2001a:31). If the element filters too quickly, the water will not be in contact with the colloidal silver for a sufficient amount of time, thus not treating the water effectively. However, if the element filters water too slowly, the user would possibly revert to using unfiltered water, due to frustration of waiting for the receptacle to contain sufficient water for use. For these reasons, the filter contains a quality control measure: a pre-defined flow-rate range, defined by Potters For Peace. Flow-rates outside this window are not acceptable, and the filters should not be released from the manufacturer but rather be discarded (Lantagne, 2001a:31).

3.3.2.4 Composition of the assembled Filtron filter unit

The assembled Filtron filter comprises a large 40 litre moulded plastic receptacle into which a ceramic pot shaped filter element is suspended (fig. 3.4 & 3.5). This ceramic filter is suspended by a plastic retaining ring that fits onto the top rim of the receptacle. A loose plastic covering lid with an incorporated handle covers the ceramic filter and rests on the retaining ring. A sub-assembled spigot is fitted to the lower side of the receptacle. Filtered water is tapped from this spigot. The receptacle and lid of the Filtron filter are not necessarily custom-designed specifically for the filter. These appear to be existing mass manufactured components that have been assembled to complete the product. This is beneficial, as it saves costs. However, it also implies that the components are not designed specifically for their functionality.



Fig. 3.4 Assembled Filtron filter



Fig. 3.5 Filter components before assembly

3.3.2.5 Manufacturing and assembling the Filtron filter unit

The spigot is imported as a loose, sub-assembled component. All spigots are shipped in one cardboard box. This allows for the receptacles to stack effectively into piles. For assembly, the spigot is then inserted from outside the receptacle through a hole in the receptacle wall (fig. 3.6 & 3.7). A silicone sealing washer prevents water leakage.



Fig. 3.6 Spigot and receptacle. Note the hole in the receptacle into which the spigot will be assembled. The piece of plastic from the hole lies next to the spigot



Fig. 3.7 Spigot attached to receptacle



Fig. 3.8 The filter retaining ring is placed onto receptacle

The filter retaining ring fits snugly around the top rim of the receptacle and is forced on, creating a secure friction-fit (fig. 3.8). The filter element is lifted by its rim by using both hands, because of its fragility (fig. 3.9). The fragility is due to the characteristics of the ceramic material used for manufacturing the filter. The covering lid contains an incorporated lifting handle allowing for easy lifting. The lid rests loosely on the retaining ring, protecting the filter from dust.



Fig. 3.9 The filter element is lifted by the rim



Fig. 3.10 The filter element is lowered into the retaining ring



Fig. 3.11 The filter element rests on the retaining ring, suspending it in the receptacle

3.3.2.6 Operation of the Filtron filter unit

The covering lid is removed, and the ceramic filter element is filled with the water to be filtered (fig. 3.12 & 3.13).



Fig. 3.12 Filter element filled with water

The water then saturates the ceramic filter element and slowly filters through the pores at a rate of between 1.5 to 2.5 litres per hour, provided the filter is kept full (rate defined on the Filtron leaflet received with the shipment of Potpaz filters, see annexure 3). The filter needs the weight of the unfiltered water in the element to create sufficient pressure to push the water through the pores. The water filtering through the filter element drips into the receptacle where it is stored, ready for consumption (fig. 3.13).

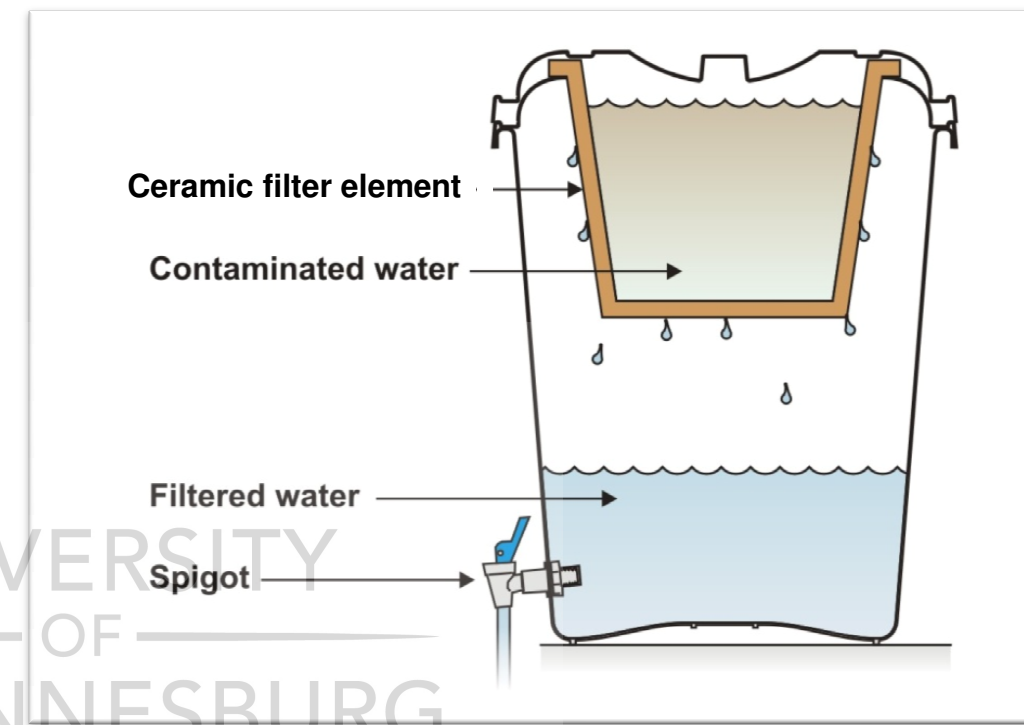


Fig. 3.13 Operation of the Filtron filter

3.3.2.7 Manufacturing of components

The majority of the components comprising the Filtron filter are manufactured by mass-production. The cost of creating the required tooling for the injection moulding tools would be high, but can be amortised with the high volumes of quality products injection moulding affords. The only component not manufactured by using injection moulding is the ceramic filter element. The filters are manufactured using a press-form mould (Annexure 21), shaping the ceramic into a flowerpot form.

3.3.2.8 Covering lid and filter retaining ring

The mould that was used for moulding the components is a two-part open and shut mould with no undercuts (fig. 3.15). The lid and retaining ring are made from the same plastic moulding. For manufacturing of the filter retaining ring, lid mouldings are altered. A large hole is cut from

the inside of the lid, allowing space for the filter to fit (figs.3.14 & 3.16). This produces a relatively large amount of material wastage. Although this plastic off-cut can be re-ground and recycled, the processes require time and effort, increasing unit costs.



Fig. 3.14 Covering lid and retaining ring

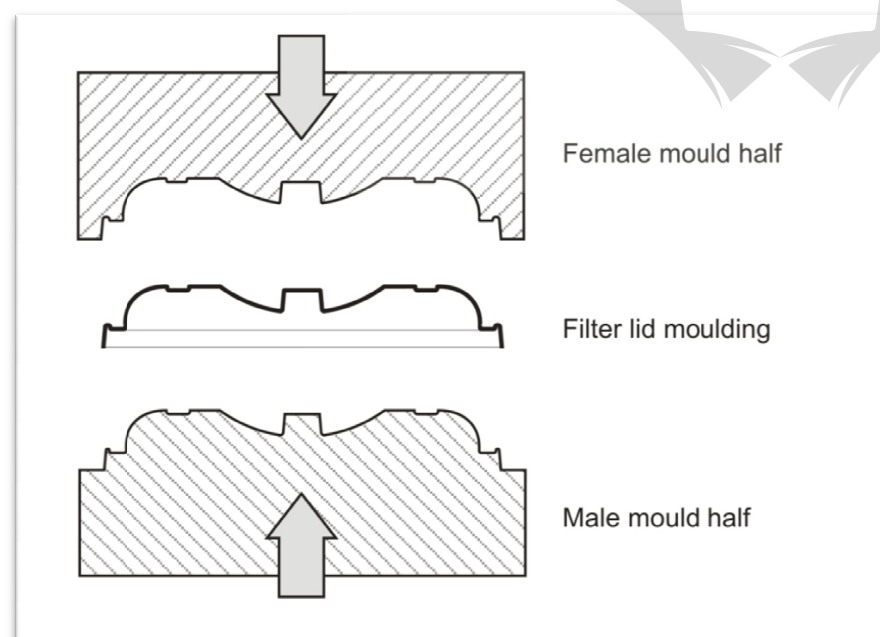


Fig. 3.15 Moulding of covering lid/retaining ring

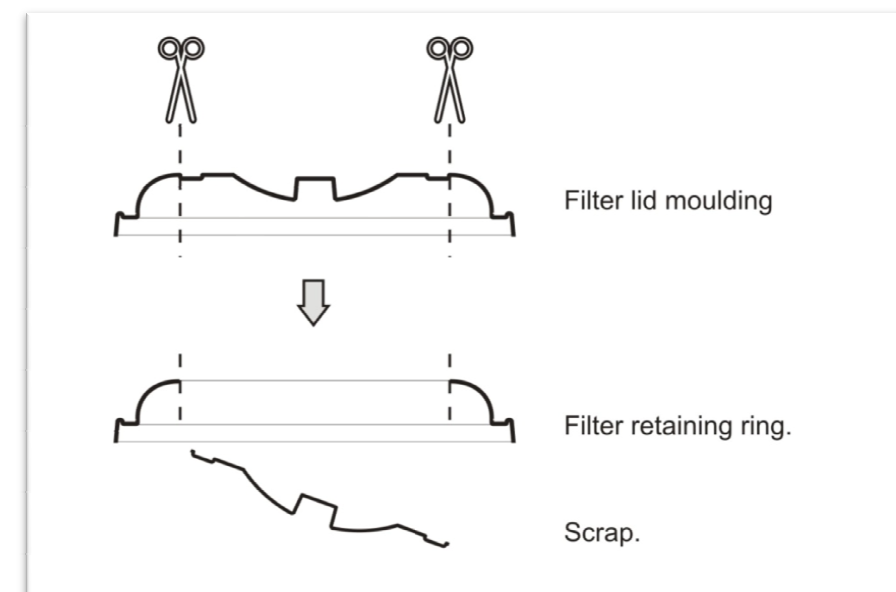


Fig. 3.16 Cutting lid moulding to create retaining ring

3.3.2.9 Plastic receptacle

The majority of the receptacles used for Potters For Peace filters are plastic receptacles that are injection moulded using Polypropylene (fig. 3.17 & 18). In some instances, the lower receptacle is ceramic. The benefit in the latter is that it can also be manufactured on a community level, thereby creating employment. Another benefit of a ceramic receptacle is that, if left unsealed, it provides cool water, due to the water permeating the ceramic, allowing for evaporative cooling to take place¹³. The disadvantage is that the filter unit will be much heavier and more fragile than its mass produced plastic counterpart. When field testing operational filters, it was evident that "... *plastic receptacles have been shown to be more effective in microbial reduction than [sic] ceramic receptacles*" and are therefore preferred (PFP, 2006h:18). The reason for this is that a biofilm can form more easily on the porous surface of ceramic than on the smooth surface of plastic.

¹³ Evaporative cooling is a physical phenomenon where evaporation of water into surrounding air cools an object or a liquid in contact with it.



Fig. 3.17 Plastic receptacle

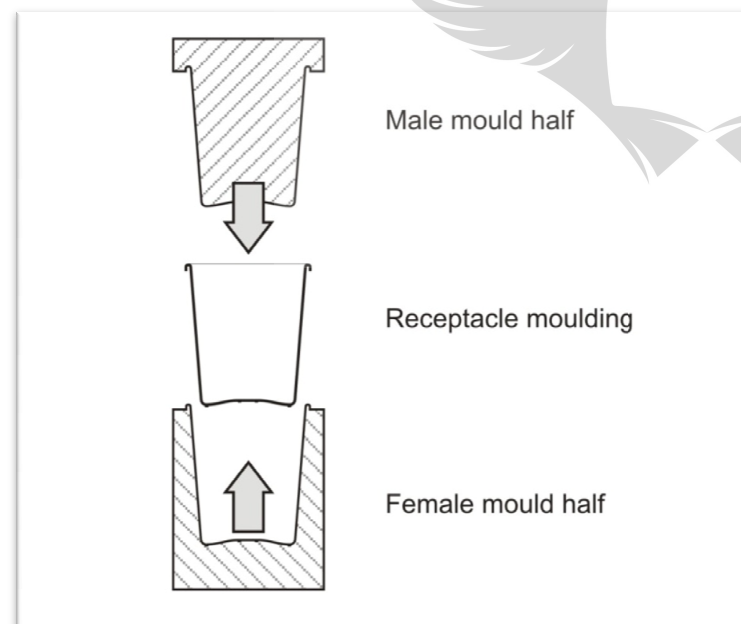


Fig. 3.18 Injection moulding receptacle

3.3.2.10 Spigot

The spigot is a standard component (fig. 3.19). The only requirement for filter assembly is for it to be assembled onto the receptacle. No tools are required as the nut can be tightened by hand to a satisfactory tension with the silicon washer, to prevent leaking.

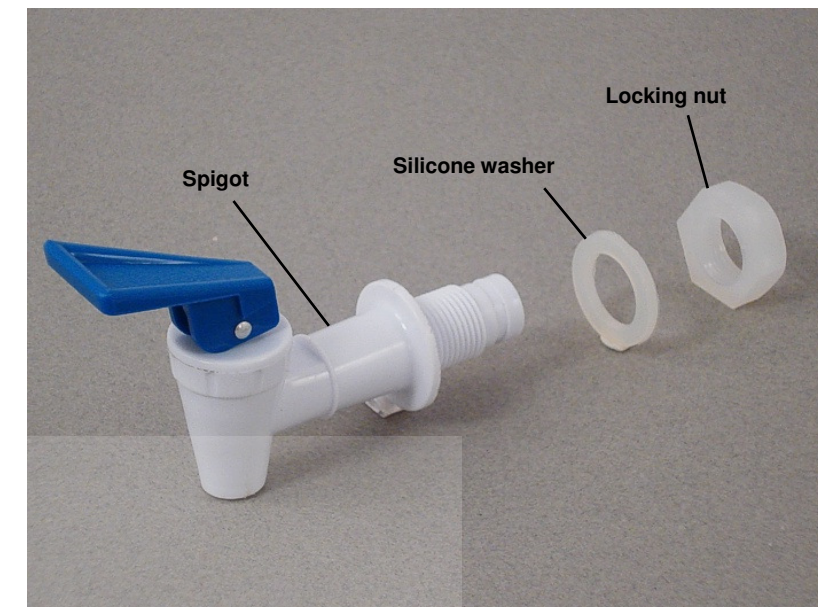


Fig. 3.19 Spigot, including locking nut, and silicone washer

3.3.2.11 Filtron ceramic filter element

Potters For Peace assists in starting factories that manufacture Potpaz filter elements (PFP, 2006b). The filter is currently being manufactured by many factories and community potting projects across the world¹⁴ (PFP, 2006i:3). The manufacturers use various methods to make the filters, some yielding higher output than others. The lowest output will be by hand, or spun on a wheel, with the higher outputs being from hydraulic press-form moulds. Ceramic filter shapes vary considerably from various parts of the world (annexure 19). Clay is used to manufacture the ceramic filter (fig. 3.20). This is generally clay from a local clay source close to the manufacturer, or it consists of clay castoffs from the local brick and roof tile factory (annexure 20). This type of clay is preferred, as it has been aged for several weeks and has better properties than clay taken directly from the source (PFP, 2006e). The ceramic filter has an internal volume of eight litres, and a general wall thickness of approximately 10mm. Eight litres are sufficient to supply enough drinking water for a family of four for one day, on the estimate of each person consuming two litres of water daily.

¹⁴ Including Yemen, Kenya, Benin, Colombia, Tanzania, and Cambodia (Potters for Peace newsletter, February 2008:3)



Fig. 3.20 Filtron ceramic filter element



Fig. 3.22 Boxes containing filters stacked to a height of five boxes

3.3.3 The Filtron filter: Packaging

The Filtron filters elements were packed in cardboard boxes with shredded cardboard as packaging material, to support and protect the element (fig. 3.21). The boxes were stacked at a maximum height of five boxes in the shipping container (fig. 3.22).



Fig. 3.21 Filter packed with shredded cardboard

a. Observations of specific filters used in the Point-of-Use project.

The shipment of Filtron filters were packed in a standard shipping container in Ghana and shipped to Cape Town Harbour. From there, the container was freighted overland on a large truck, to Louis Trichardt (fig. 3.23). The filter units were unloaded and stored for quality testing prior to implementation. One filter box was damaged. However, the contained filter remained intact (fig. 3.24)



Fig. 3.23 Unpacking of Potpaz filter components



Fig. 3.24 Damaged filter element box

3.3.4 Flow-rate testing of Filtron filters

For the purpose of the point-of-use project, the project leaders decided that it would be in their best interest if the flow-rate of each filter was tested and documented before the filters were implemented in the households. This was a quality control measure that should be performed by the filter manufacturers of the filters. By doing this, the flow-rates were able to be used as an indicator of the effectiveness of the filters. Furthermore, it was possible to observe a link between instances where the users had discontinued use of the Potpaz filters, due to the slow filtration rate of the ceramic filter (each filter was numbered to keep track of its use in the households).

3.3.4.1 Process of flow-rate testing

Filters were filled with water (fig. 3.25) and were allowed to filter for one hour. During that time, the water level was monitored and continually topped up as the water level dropped. This ensured a maximum filtration rate of the filters (leaflet supplied with filters, see annexure 3).



Fig. 3.25 Filters were filled with water, and the water level constantly monitored

Once the hour had passed, the flow-rate was documented (person in black shirt, fig. 3.26), and the corresponding number was written onto the rim of the filter element (refer to fig 3.26 & 27). Each filter was given a unique number, making it possible to refer back to the findings once the filter had been implemented in the households (fig. 3.27).



Fig. 3.26 Measuring of filtered water. Note the filter is lifted together with the retaining ring (person in yellow shirt)



Fig. 3.27 Top view of filter rim showing the filter number

3.3.4.2 Results of flow-rate testing

With regard to the flow-rate of Filtron filters, three different flow-rate specifications are provided in three different sources, being the Potters For Peace website, the leaflets received with the shipment of Filtron filters, and Lantagne's report 1 on the intrinsic effectiveness of the Potpaz filters. The flow-rate testing results have been compared to the flow-rate ranges of each of these three sources and is presented graphically (fig. 3.28, 3.29 & 3.30).

(a) Filtron leaflets

According to the leaflets received with the Filtron filter shipment, the flow-rate of the filter should have been in the range of 1.5 and 2.5 litres per hour (annexure 3). The tested flow-rates, however, showed that of the 403 filters tested, only 38% had a flow-rate of between 1.5 and 2.5 litres per hour (152 filters). This is illustrated on the flow-rate diagram (fig. 3.28), with the green bars showing the number of filters that had an acceptable flow-rate specified in the leaflet. The red bars show the number of filters that did not fit into the acceptable flow-rate range.

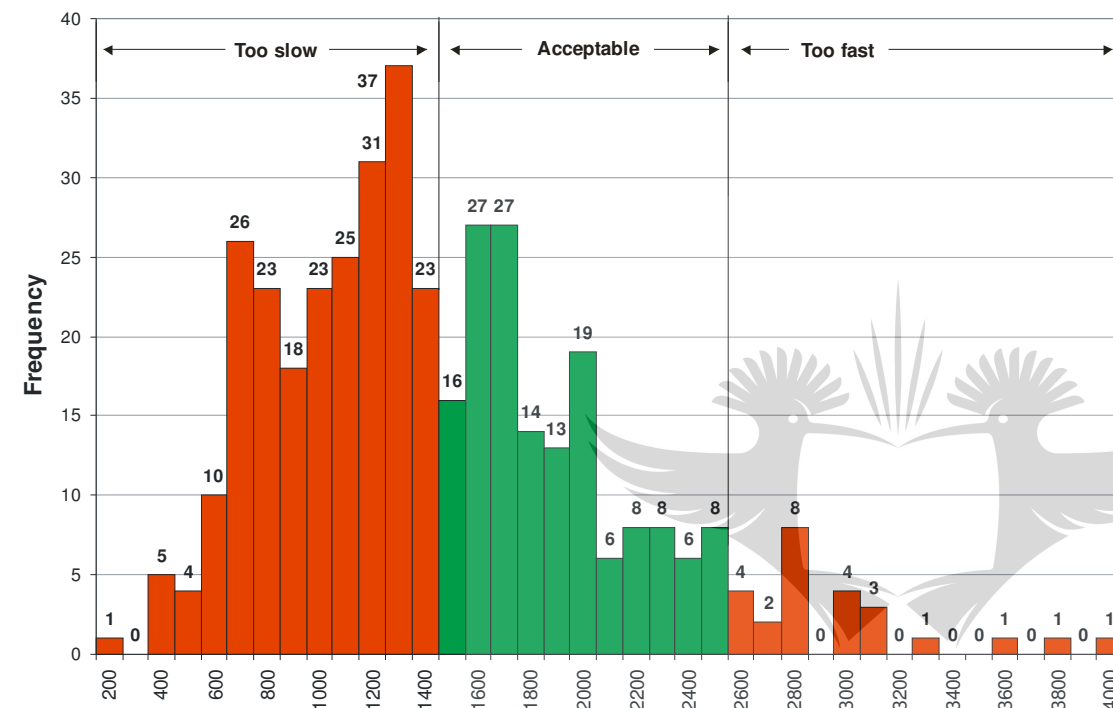


Fig. 3.28. Flow-rate testing results compared to Filtron leaflet

(b) Potters For Peace website

On the Potters For Peace website, it is stated that a benchmark filtration rate should be between one and three litres per hour (PFP: 2006c). If this were applied to the flow-rate testing conducted (fig. 3.29), only 77% of the filter shipment fits in the benchmark range (309 filters), with the majority of the unacceptable filters filtering water too slowly (87 filters).

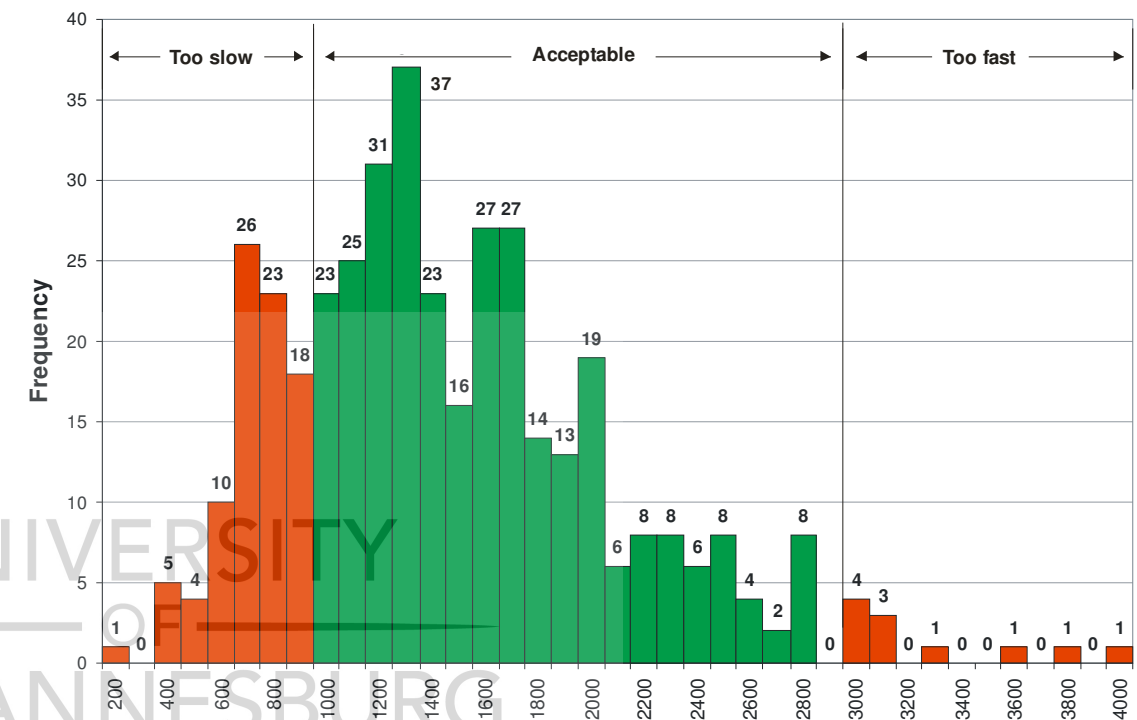


Fig. 3.29. Flow-rate testing results compared to Potters For Peace website

(c) Lantagnes report: Intrinsic effectiveness

In Lantagne's report on the intrinsic effectiveness of the Potpaz filters (Report 1), it is stated that at the Potters For Peace factory all filters are manufactured to have a flow-rate of between one and two litres per hour. If the flow-rate does not fit into this range, the filters are discarded (Lantagne, 2001a:31). If that were the case at the factory manufacturing the Filtron filter in Ghana, 37% (148 filters) of the entire shipment of filters should not have been sold and shipped to South Africa, and should rather have been discarded or destroyed (fig. 3.30).

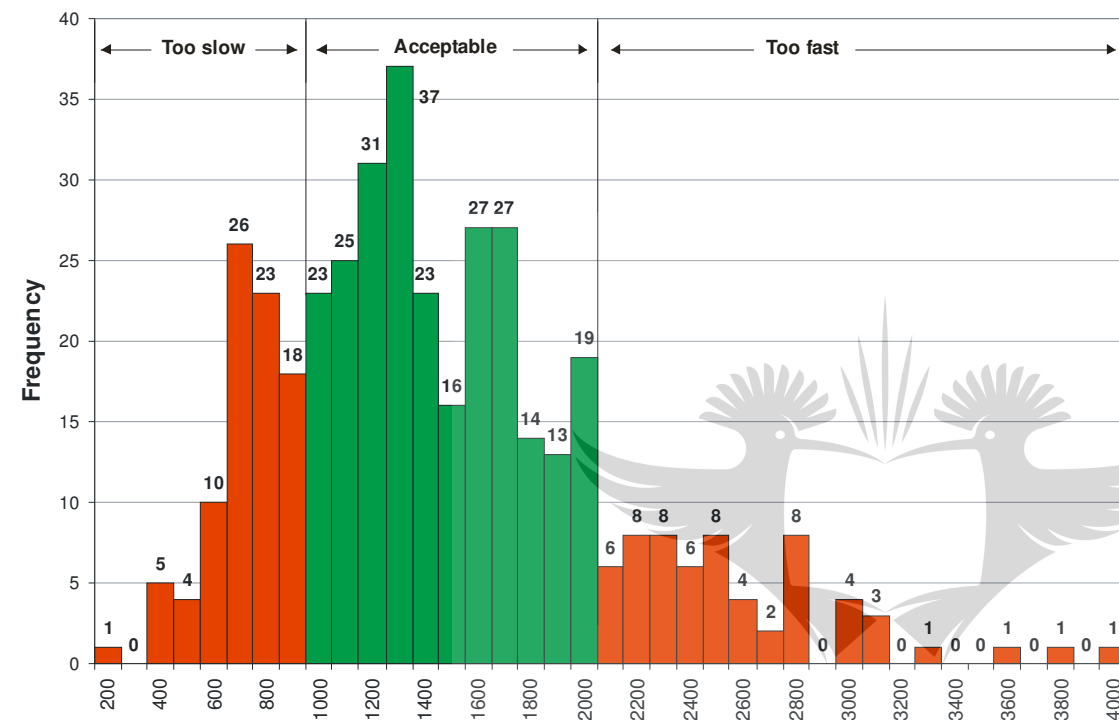


Fig. 3.30. Flow-Rate testing results compared to Lantagnes report

Table 1. Summary of flow-rates according to three different sources

| | | Filtron leaflet | Potters For Peace website | Lantagne's report |
|------------|--------|-----------------|---------------------------|-------------------|
| Too slow | Red | 56% | 22% | 22% |
| Acceptable | Green | 38% | 77% | 63% |
| Too fast | Orange | 6% | 2% | 15% |

According to all three referred sources, the flow-rate testing reveals that the tested filters do not fit into the specified flow-rate ranges.

3.3.4.3 Conclusions of flow-rate testing

It is important to have a defined flow-rate range. As stated in the colloidal silver section, the effectiveness of the filter depends on the contact time the water has with the colloidal silver contained within the ceramic filter. The filter therefore cannot filter water too quickly, thus preventing the water from being treated by the colloidal silver. If the flow-rate were to slow, the user may not be willing to wait long for water to filter, causing him/her to revert to using unfiltered water. For example, the slowest flow-rate in the entire shipment of filters, if used in a household, would force the user to wait an hour for 200 ml of water to filter.

The effectiveness of the Potters For Peace filter has repeatedly been demonstrated. However, it is necessary that the standard of production and quality control remain at a constant level. The necessary infrastructures are in place, and the filter manufacturing factories/community projects have the training and equipment needed to maintain such a level. This is relevant to the design of the improved water filter, as the effectiveness of the ceramic filter depends on the quality of the manufactured component. If ceramic filters are to be locally manufactured, it will be important to include adequate quality control systems in production, to assure a well designed, reliable product.

3.3.5 Self-assessment forms

In the point-of-use project, I was responsible for the Filtron filter assessment. This implied monitoring of whether or not the filter users were maintaining the Filtron filters correctly. The users were trained in the correct use and cleaning of the Filtron filter unit upon receiving the filter. They were also supplied with laminated instruction leaflets (in the Tshivenda language) on how to use the filter for the first time, as well as normal routine use and cleaning of the filter receptacle and ceramic filter element (appendixes 6, 7, 8 & 9). The community users were required to complete forms regarding use and cleaning of the filter daily (fig. 3.31 for example.).

644
5

Nomboro ya mudi: Gugan 079 Mathomo: 07/01/08 Magumo: 13/01/08

Thoho ya Tshitentsi: Phitanga Redoloburano

| | Tsumbo | Musumbuluwo | Lavhuvhili | Lavhuraru | Lavhuna | Lavhutano | Mugivhela | Sondaha |
|---|--------|-------------|------------|-----------|---------|-----------|-----------|---------|
| Vho Ka/wana ngafhi madi avho | | | | | | | | |
| Phaphu/Bommbi | | 7-01 | 8-01 | 9-01 | 10-01 | 11-01 | 12-01 | 13-01 |
| Owedzho | | | | | | | | |
| Mulambo kana Mugero wa madi | | | | | | | | |
| Tshisima | | | | | | | | |
| Ndi lili he vha tanzwira ravha/bakete? | | | | | | | | |
| Tambani zwanda nga tshisibe | | | | | | | | |
| Tanzwani ngomu ha ravha/bakete nga madi | | | | | | | | |
| Tanzwani ngomu ha ravha/bakete nga tshisibe na madi | | | | | | | | |
| Tukisani ravha/bakete | | | | | | | | |
| Ndi lili he vha tanzwira tshitudo (sha vumba)? | | | | | | | | |
| Tambani zwanda nga tshisibe | | | | | | | | |
| Tanzwani phutlhi | | | | | | | | |
| Fhalani ngomu ha tshitudo nga bulatsho | | | | | | | | |
| Tukisani tshitudo | | | | | | | | |

Note: Dzholani ntha
Hu dosha na zefanyiso tshini ha mbuno inwe na inwe
Hezwi zwilou u thusa khawo wana munhango nga tshitudo

Fig. 3.31 Completed self-assessment form, form #694

These forms were gathered and the data analysed. This made it possible to observe how many users continued to use the filter as initially instructed, as well as the ways in which they deviated from these instructions. This was important because, if the filter is not being used or cleaned correctly, a strong possibility arose that the water tapped from the spigot may still be contaminated, even after having passed through the filter element.

3.3.5.1 Process of collecting self-assessment data

Blank copies of the form shown in fig. 3.31 were supplied to each household to be completed daily. This was done by marking what activity was completed on which day in relevant blocks (fig. 3.31, & annexure 10 & 11). These forms captured/collected the following data regarding correct or incorrect filter cleaning requirements, as well as other data which could be utilised by the Point-of-Use project leaders:

- Where did you get your water from (and on which day?): Tap, borehole, river/canal or spring?
(This data was to be utilised by the microbiologists).
- When did you clean the plastic receptacle?
- When did you clean the ceramic filter?

The total sample group for this data totals 32 households, all using Filtron filters. Results from the analysis of the self-assessment are presented in table 2.

3.3.5.2 Table 2. Results from self-assessment form data

| Number of households included | Number of households of the total 32 household sample group | Percentage of sample group |
|-------------------------------|---|----------------------------|
|-------------------------------|---|----------------------------|

| Water Collection: | | |
|---------------------------|----|-----|
| Community tap/ standpipe. | 28 | 88% |
| Springs | 3 | 9% |
| Borehole | 1 | 3% |

| Filter Cleaning: | | |
|-----------------------|----|-----|
| Correct | 11 | 35% |
| Deviated slightly | 11 | 35% |
| Deviated considerably | 10 | 31% |

| Of Cleaning deviations: | | |
|--|----|-----|
| Number of deviations due to excessive receptacle and/or filter cleaning: | 17 | 85% |
| Number of deviations due to receptacle neglect (not getting cleaned): | 3 | 15% |

3.3.5.3 Conclusions from self-assessment form data

Thirty five percent of the households followed the initial instruction correctly (table 2). This does not imply that the remaining 65% of the participating households were not consuming potable water. Of the households who deviated from the initial cleaning instruction, 85% deviated by conducting the routine cleaning of the receptacle or filter more often than instructed. The household that conducted filter cleaning most often, in a timeframe of three months, washed the ceramic filter element twelve times and the plastic receptacle fifteen times. Correct cleaning of the filter element itself would entail the filter being cleaned only when the flow-rate decreases considerably (generally once per week) and the plastic receptacle being cleaned once per month. The increased number of cleaning occurrences should not affect the microbial quality of the filtered water adversely, thus providing users potable water, although instructions were not adhered to.

3.4 Field research

The field research part of the data collection consisted of the analyses of data gathered from households in the rural areas of South Africa by conducting interviews, personal observations and by taking photographs. Consent was received from each household, granting permission for the inclusion of their data in this dissertation. These households were chosen because the leaders of the point-of-use project had conducted previous research in the same villages and had the coordinates of each of the households. Since addresses of these households The documenting of these households was undertaken by using a handheld GPS¹⁵ to log the co-ordinates of each household. However, for the purpose of the field research conducted for this MTech project, only the intervention households were to be visited¹⁶. Each household code relating to their GPS co-ordinates was included on the questionnaire completed in that specific household (fig. 3.32).



Fig.3.32 GPS navigation utilised for locating households

It was therefore also possible to document the interview schedules, personal observations and photographs for each household with the same reference code. As a result, the findings from the three types of data could be presented together. The combined body of data was divided into sections pertaining to placement; design aspects; and use. **Placement** refers to where the Filtron filter is kept in the households, i.e. in what room, on what surface, as well as its proximity to the water source in the households. **Design aspects** refer to aspects of the Filtron water filter. This reveals areas where the filter operates well, as well as where possible

¹⁵ Global Positioning System, The one utilised was a Garmin GPSmap 60CSx.

¹⁶ Households who have been using the Filtron filter for more than two months.

improvements can be made. **Use** refers to the use and cleaning of the filters, problems encountered, and areas of satisfaction. In the data analysis it was possible to compile a list of successful design aspects regarding the Filtron filter, as well as areas where improvement is possible.

3.4.1 Data gathering tools utilised

(a) Interview schedule (refer to annexure 14 & 15)

An interview schedule was compiled to be used when conducting interviews with the users of the Filtron filters (fig. 3.33). These were translated and back-translated into the Venda language by translators at the University of Venda. The questions included in the schedule were both open-ended and closed questions. The resultant responses provided both qualitative and quantitative data.



Fig. 3.33 Venda-speaking interviewer conducting an interview with a Filtron user

(b) Personal observations (refer to annexure 17 & 18)

Personal observation forms were compiled, where a single form was completed at each household as well as at each spaza¹⁷ shop visited, this is further explained in point (e) of this list (annexure 18). The forms included questions of observations to be made regarding the three focused areas of **placement**, **design aspects** and **use**.

(c) Photographic documentation

Where possible, photographs of the filter, the condition of the filter, where it was kept, on what it was kept, were taken at all the interviews. Key points that were important to be photographed for understanding the households were highlighted on the personal observation form, (annexure 17), similarly, for spaza shops.

(d) Household visits

Each household visit began with the Venda interviewer explaining who I was and my reason for visiting the households. Thereafter, the interviewer requested signed consent for conducting the interview. While the interview was being conducted, personal observations regarding design aspects were made. This included where the filter was kept, on what it was placed, the condition of the filter, among other points (Annexure 18).

(e) Spaza shop visits

Spaza shops were visited to observe the areas in the shop where water filters could possibly be stocked (fig. 3.34). If shop owners were willing to participate after a background explanation of the project, personal observations regarding the spaza shop were made (annexure 18) and photographs taken.



Fig. 3.34 Observation of stocking areas in rural spaza shops

(f) Potter visits

Potters in the Venda area were visited to gain an understanding of existing potting practices in the rural areas of the Vhembe district. A community potting project and local potters from some of the villages where Filtron filters had been implemented, were visited (fig. 3.35). Photographs were taken of the ceramic products and equipment used for their production.



Fig. 3.35 Potters from a community potting project, Limpopo province

¹⁷Spaza shop: an informal business in South Africa, usually run from home. It serves as a convenience shop and sells everyday small household items.

3.4.2 Field research analysis, conclusions and possible solutions

This section presents analysed data from the combination of the interview schedules, personal observations and photographs conducted at all the relevant locations (table 3).

Table 3. Breakdown of field research interviews and observations

| | |
|---|----|
| Total number of households visited | 81 |
| Total number of household interviews/observations | 65 |
| Of all households visited, interviews were conducted at 80%, (20% of the households were visited without interviews/observations being conducted) | |
| Total number of villages visited | 19 |
| Total number of villages where interviews were conducted | 15 |
| | |
| Total number of spaza shops visited | 7 |
| Total number of potter interviews | 2 |

The data were grouped into: analyses of placement, design aspects, and use, including the data from the spaza shop and potter visits. Patterns that became evident with the gathering and analyses of the data allowed for areas of development from the existing Filtron filter. Lastly, points that I observed during the flow-rate testing, handling, implementing, and gathering of field data have been included, to cover a complete analysis of the Filtron filter. The following is a summary of the topics expanded on in the section to follow.

(a) Analysis of placement

- In which room is the Filtron filter kept?
- On what surface is the Filtron filter placed?
- Does this surface form part of the surrounding area or has it been specifically constructed for the filter?
- How does one retrieve water from filter? (stoop, kneel, bend, stand up straight)
- How high is the placement surface above the floor?
- If you could have the Filtron filter placed at any height, what height do you think would be ideal?

(b) Analysis of design aspects

- Has the filter ever been knocked over?
- Have you experienced any stability problems?
- How do you lift the lid?

- Do you use a specific container, or not?
- How do you hold the container and open the tap?
- Are any parts of the filter broken or damaged? If so, what parts?
- Where is the Filtron filter located in relation to stored water?
- Have any alterations been made to the Filtron filter?

(c) Analysis of use

- Is there a difference in the taste of the filtered water?
- Do you like the taste of filtered water?
- How many times do you fill the filter per day?
- How do you fill the ceramic filter? (scooping from drum, pouring from large bottle, etc.)
- Is the Filtron filter in operation?
- Are there any insects underneath the lid?
- Do you experience any problems when filling the filter?
- Do you experience any problems or irritations when cleaning the ceramic filter?
- Does the filter's tap leak water?
- Does the filter's tap supply water fast enough?
- Does the filter provide sufficient water for everyone in your family?
- Does the Filtron filter look clean?
- What can be changed on the filter to make it easier to use? (comments by community member)

(d) Spaza shop visits

- Are there other products similar in form and size to the Filtron filter?
- If the improved filter were to be stocked in shelving space/shop space, where would be suitable and what dimensions would be available?

(e) Potter visits

- Potters in the Vhembe region were visited and their manufacturing capabilities documented. This provided insight into their methods of manufacturing ceramic items.

(f) Personal observations

- General trend of low water levels in receptacles.
- Mistaken lifting handle under rim proves un-ergonomic.
- Household does not understand that the spigot has two positions: temporary flow, and locked flow.

Each of the above points will now explained with statistic from the analysed data, together with a written analysis of the data, and finally, design implications relevant to the a filter for use within a rural South African setting.

3.4.2.1 Analysis of placement (location in the house)

3.4.2.1 (a) In which room is the Filtron filter kept?

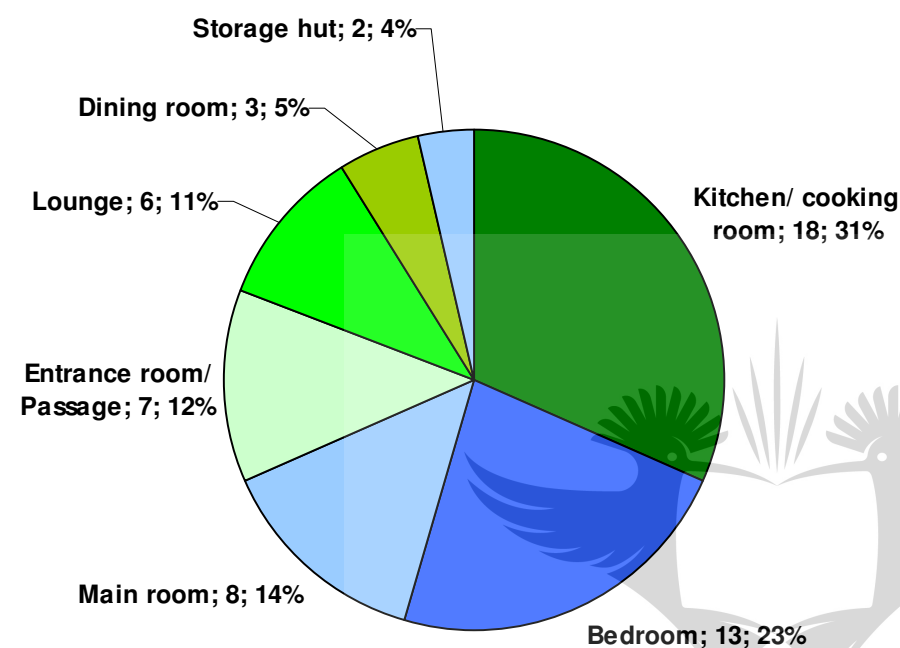


Fig. 3.36 In which room is the Filtron filter kept?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.36). The main room refers to the main room in the house (fig. 3.37). Some households live in only one room, used for all household activities, such as cooking, food preparation, storage and sleeping.



Fig. 3.37 Filter in main room

The majority of the houses kept their filter in rooms where there was a relatively large amount of 'through traffic' (fig. 3.38), with only two houses (4%) keeping their filter in a separate storage hut.



Fig. 3.38 Filter in lounge

Design implications

The filter should be able to stand freely in the place selected by the households, not only the cooking room. It should be aesthetically pleasing and should be similarly styled to other plastic items present in the household.

3.4.2.1 (b) On what surface is the Filtron filter placed?

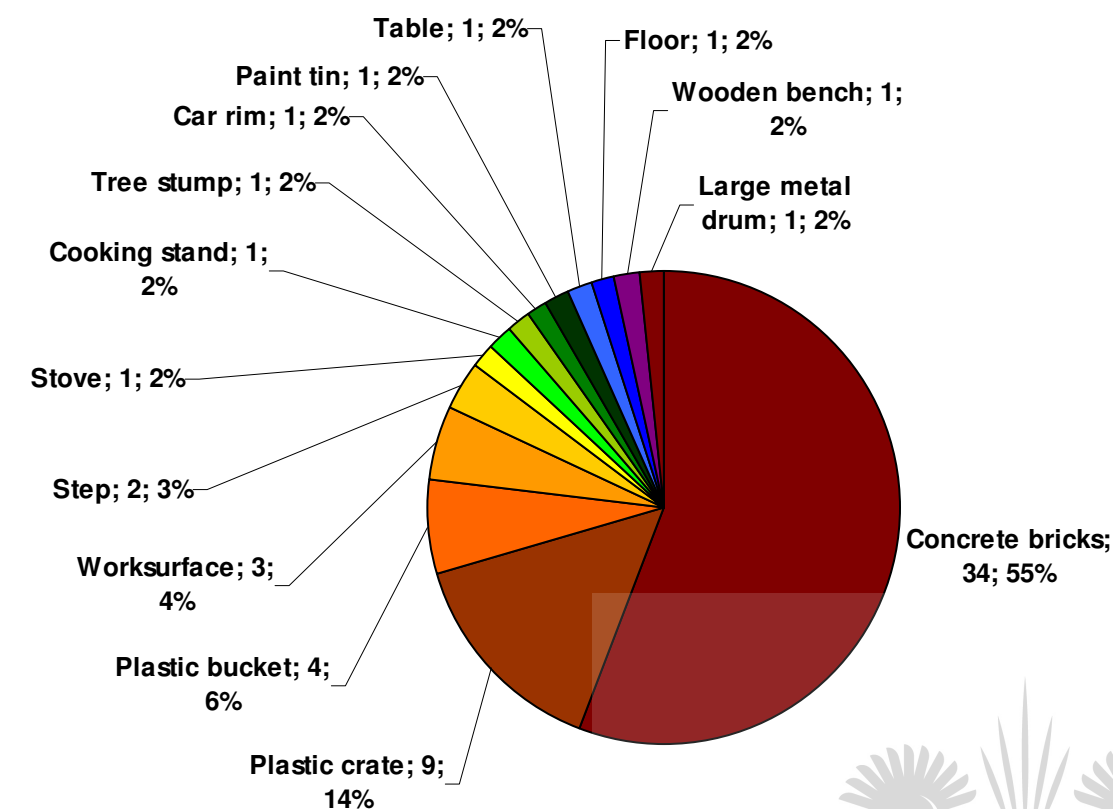


Fig. 3.39 On what surface is the Filtron filter placed?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.39). The Filtron filter should ideally be placed on a raised surface, allowing for a container to fit underneath the spigot to retrieve water from the receptacle. In more than half the households visited the filter stood on pedestals constructed of loosely packed concrete or clay bricks (fig. 3.40). Bricks were used since no other suitable surface was available.

Upon implementation, each household received a filter, and the trainer discussed with the household what available surface they had for the filter to stand on. In most cases, an existing surface, such as a kitchen counter, was not available and a surface had to be constructed. This was a problem, as the filter height therefore depended on the available resources within each household (fig. 3.41).



Fig. 3.40 A loosely stacked stock brick pedestal



Fig. 3.41 Makeshift pedestal- stock bricks wrapped in newspaper

Design implications

The filter should either be usable while resting on the floor, or able to operate without resting on the existing surfaces in the households. Methods of placement therefore need to be explored, to find a number of solutions that will suit a variety of rural households. For the filter to be usable while resting on the floor, it needs to be supplied with a stand or include an incorporated stand in the filter unit. Other solutions include suspending/supporting the filter without relying on a stand.

3.4.2.1 (c) Does this surface on which the filter stands form part of the surrounding area or has it been specifically constructed for the filter?

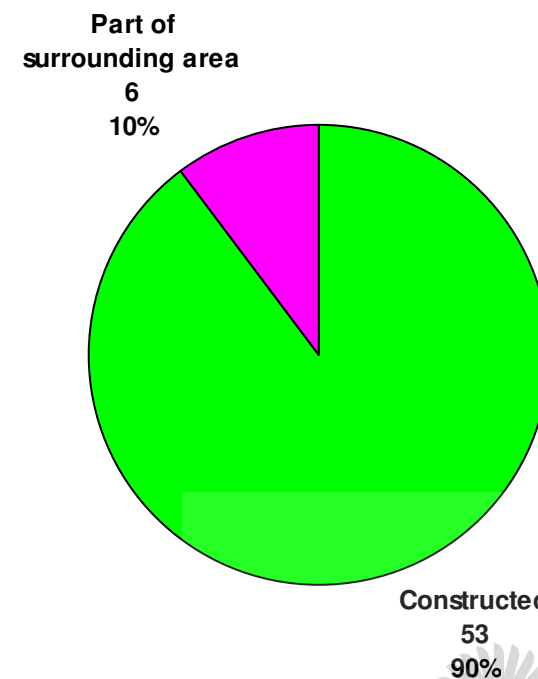


Fig. 3.42 Does this surface form part of the surrounding area or has it been specifically constructed for the filter?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.42). In only six households (10%), the Filtron filter stood on an existing surface (fig. 3.43). The remaining 53 households (90%) had to construct or improvise surfaces (fig. 3.44). The surfaces where the filters were placed, determined the height of the filter above floor level. The minimum the filter needs to be raised would be 70mm, the height of one stock brick (fig. 3.41).



Fig. 3.43 Filter on existing surface



Fig.3.44 Filter stand constructed from a plastic crate and wooden plank

Design implications

Households generally do not have a suitable surface in the surrounding area, and surfaces have to be custom made for this purpose. This issue can be solved by eliminating the need for utilising existing surfaces in each household by developing a solution where the filter does not depend on these surfaces within the household.

3.4.2.1 (d) How does person retrieve water from filter? (stoop, kneel, bend, stand up straight)

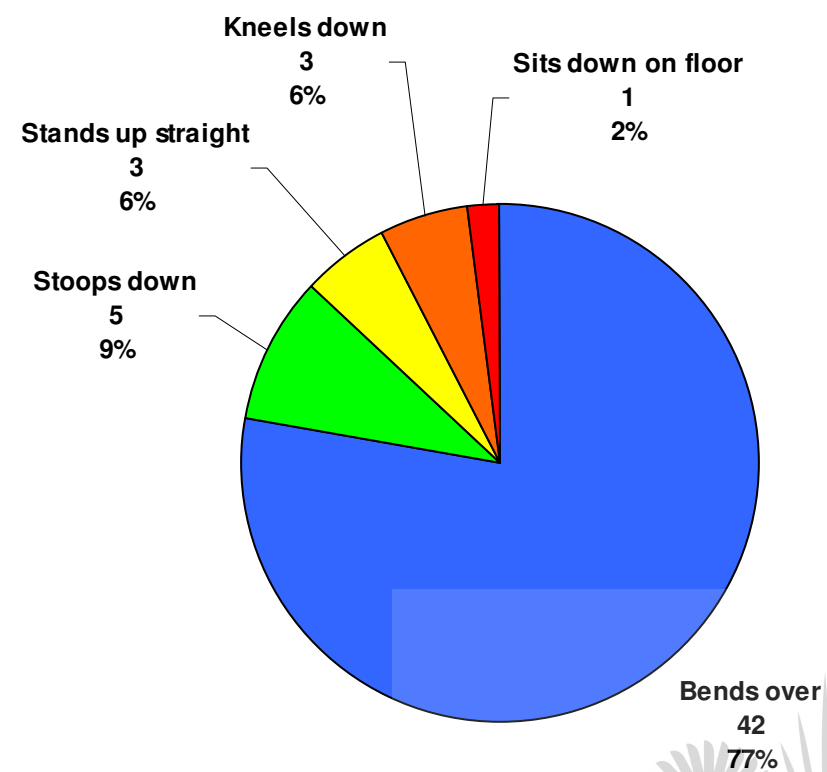


Fig. 3.45 How does person retrieve water from filter?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.45). The ideal way to retrieve water from the filter, or pour water into the filter would be to stand up straight, bending the back as little as possible. This way, the user's back would be under the least stress. Most importantly, the user should bend as little as possible while filling the filter, this is due to the fact that lifting the water container and pouring water into the filter creates more strain on ones back compared to retrieving water from the filter's spigot. *"The avoidance of stooping and of lifting and carrying loads in a bad posture is the most important medical consideration in planning housework"* (Grandjean, 1973: 34). Of the 54 responses, only three users stood up straight when retrieving water. The majority (42 users) bend over, stoop down, crouch or sit on the floor to retrieve water (fig. 3.46).



Fig.3.46 Users retrieving water from filters

Design implications

While filling the filter element with water, and retrieving water from the receptacle's spigot, the user should ideally remain in as much an upright posture as possible. This ergonomic consideration needs to be addressed to create a product which is usable, and not inflict any pain or discomfort during product interaction/use.

3.4.2.1 (e) How high is the placement surface above the floor?

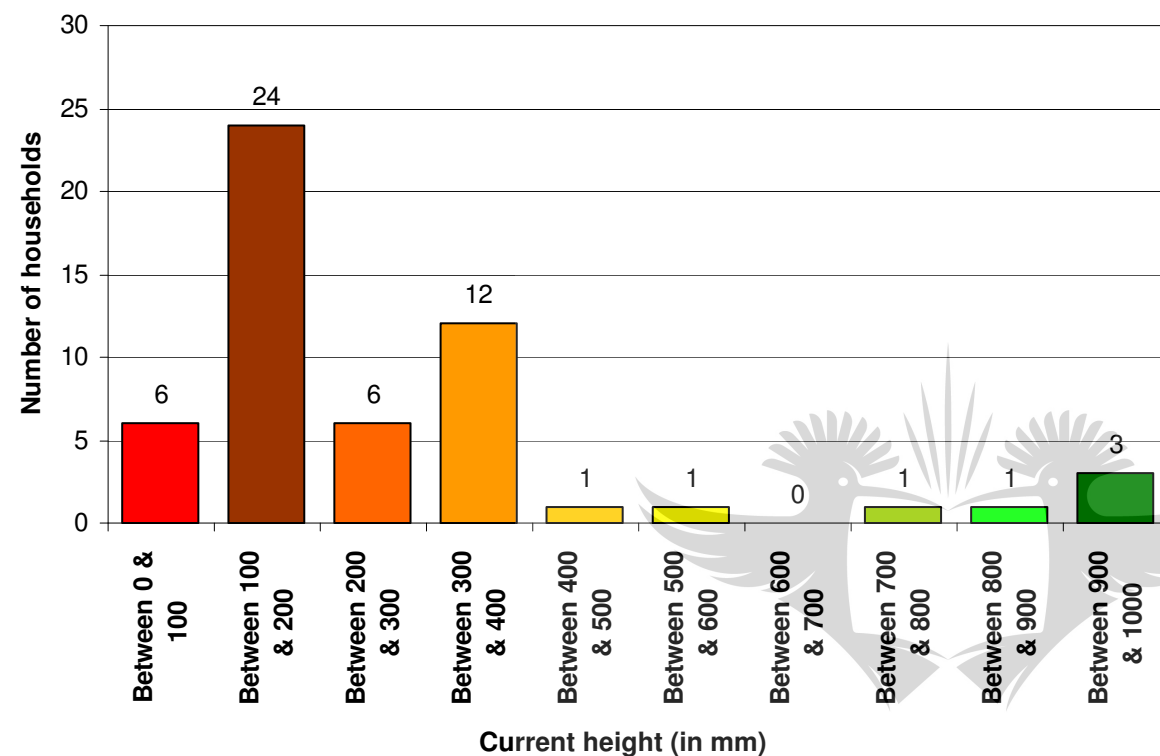


Fig. 3.47 How high is the placement surface above the floor?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.47). The majority of the households placement surfaces are between floor height and 400 mm above the floor (87 % of the 55 households). Six of these households filters (11% of the 55 households) are less than 100 mm above the floor. This is very low considering the height of a kitchen work surface in a typical suburban home that would be approximately 800 mm above the floor, the height allowing for a comfortable posture when utilising the work surface. The posture of the user during product use is important in the consideration of ergonomics and anthropometrics. In *Ergonomics of the Home*, the author indicates that the preferred height for a work surface, where the activity takes place above the work surface, is 880 mm above the ground (Grandjean, 1973: 76). For example, the height at which hotplates of the counter cooker are

situated, the height of the kettle above the floor (and any other items on the kitchen counter top evident in most urban kitchens). However, this is not the case in the cooking areas of rural households. The placement surfaces of the filters in the rural areas were low, due to the fact that the households do not have available surfaces at the ideal height. This forced users to stoop or crouch whenever retrieving water, but does allow for easy filling of the filter. If the Filtron filter did stand on an ideal work surface at 800mm above the floor it would be very difficult to lift a relatively large water container high enough to fill the filter (fig. 3.48 & 3.49).



Fig. 3.48 Filter placed on work surface



Fig. 3.49 Filter placed on cabinet

Design implications

The filter should be at a suitable height to allow the user to retrieve water without having to bend over uncomfortably, and low enough to allow the user to fill the filter element comfortably. A balance would need to be achieved:

Architects, builders, interior designers, furniture-makers and instillation firms must, whenever possible, create conditions in which the housewife can keep her back in a natural, upright attitude. Particularly important are correct working heights, adequate handles with room to grasp them, and the provision of furniture and fittings matched to the human body (Grandjean, 1973: 34).

Although it would be ideal if users in rural households did not have to bend over to retrieve water from the filter, most of the other items stored in the food preparation area are kept at floor level. The improved filter should therefore be at a height which the rural users will accept and use, taking into account their personal preferences.

3.4.2.1 (f) If you could have the Filtron filter placed at any height, what do you think would be ideal?

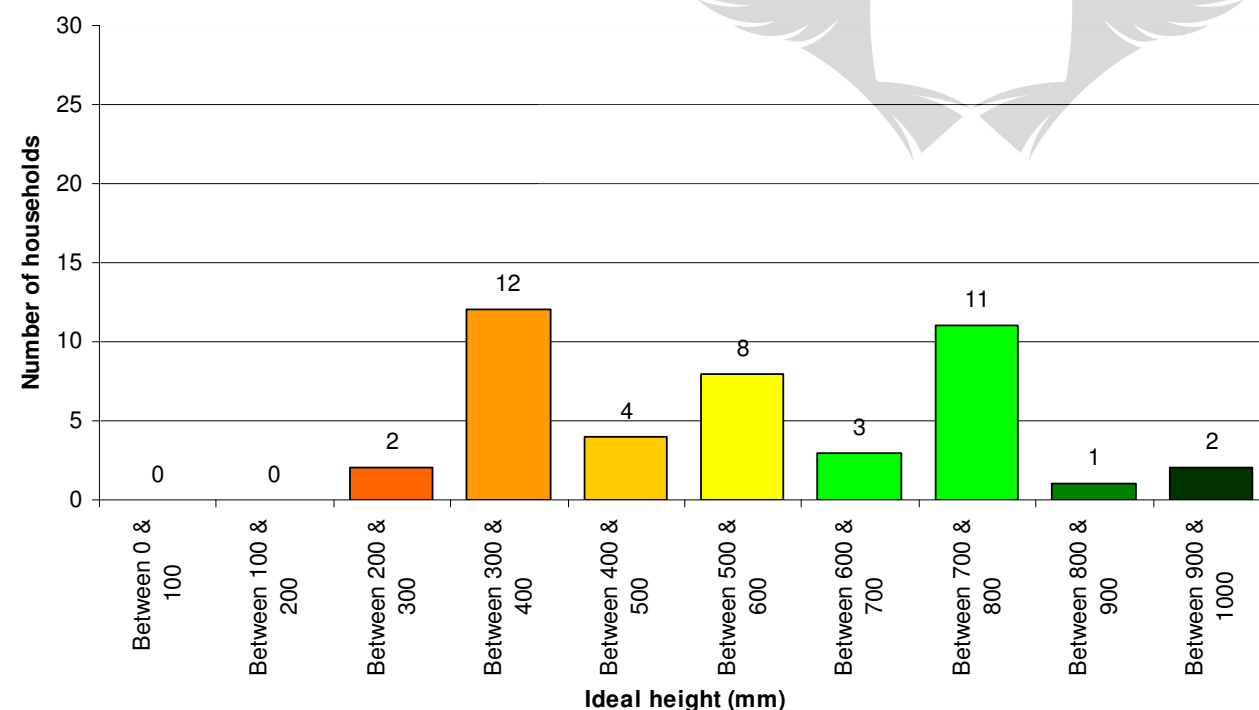


Fig. 3.50 If you could have the Filtron filter placed at any height, what do you think would be ideal?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.50). Upon asking the users if they could have the Filtron filter placed at any height, of the 44 that answered, 38 users (86%) stated that the ideal height would be between 300 and 800 mm (fig. 3.50, 3.51 & 3.52). None of the users would like the filter to be placed lower than 200 mm.



Fig. 3.51 User indicating preferred height 1



Fig. 3.52 User indicating preferred height 2

From my observations, many households do not have a counter top on which food preparation is done. Some households use a small table, and some work on a mat on the floor.

Design implications

The improved water filter should be used effectively by the rural users in their existing cooking areas. The height of the filter should be usable and at a height preferred by the users, while at the same time, be manufactured at as low a price as possible. A compromise between filter stand height and manufacturing cost will have to be made. The higher the stand (to a point), the easier the filter filling and operation will be (e.g. 700 mm). However, the higher the stand, the more material will be used in the manufacturing process, thereby increasing the production cost. With regard to the users, the ideal height of the current Filtron filter fits into a range of between 200 mm and 800 mm. A compromise between filter stand height, and manufacturing cost per filter will have to be reached. This refers to material cost and application. The filter design could include a stand that would lift the filter above the ground, but at the same time, the filter could be able to stand on a flat surface, without the user needing to purchase the stand. The placement height of the improved filter design could be variable, allowing for adjustment, with the user having the option to determine the height.

3.4.2.2 Analysis of design aspects

3.4.2.2 (a) Has the filter ever been knocked over?

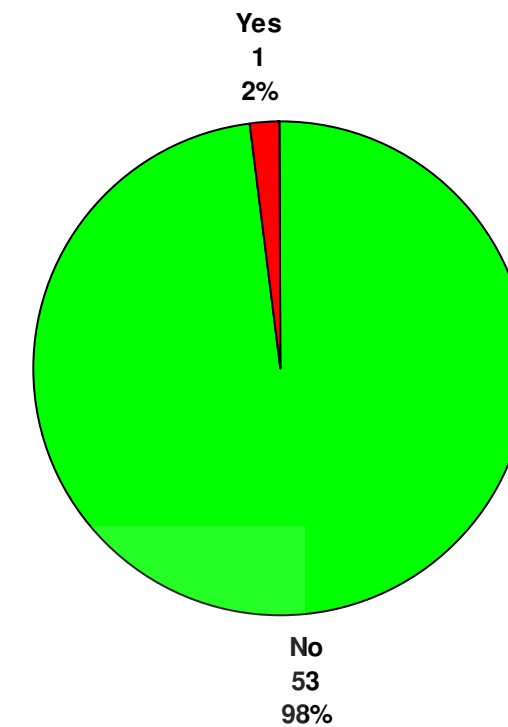


Fig. 3.53 Has the filter ever been knocked over?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.53). Of the 54 users who responded, only one reported that the filter had been knocked over. This shows that the filter is stable, and the users are careful when using it. Even with this statistic, several of the households have been observed to have unstable filters because of the unevenness of the surfaces where they place the filters, as well as the type of surface on which it has been placed. The stability footprint of the Filtron filter is Ø280 mm, the height of the assembled Filtron filter being 500 mm. The filter is inherently top-heavy when there is no water in the receptacle, due to the position and weight of the ceramic filter element. One household placed their filter on an inverted plastic bucket that had a smaller surface area than the base of the filter receptacle (fig. 3.54).



Fig. 3.54 Filter on an inverted bucket

One would assume that this filter would be knocked over very easily. However, it had not been knocked over for a duration of more than two and a half months, illustrating the filter's importance for the household.

Design implications

The form of the existing Filtron filter is sufficiently stable. The improved filter should be stable, no matter the surface on which it rests. This is due to the fact that the ceramic filter element could break if the filter unit gets knocked over. Therefore, consideration needs to be given to inherent stability in the improved filter design.

3.4.2.2 (b) Have you experienced any stability problems?

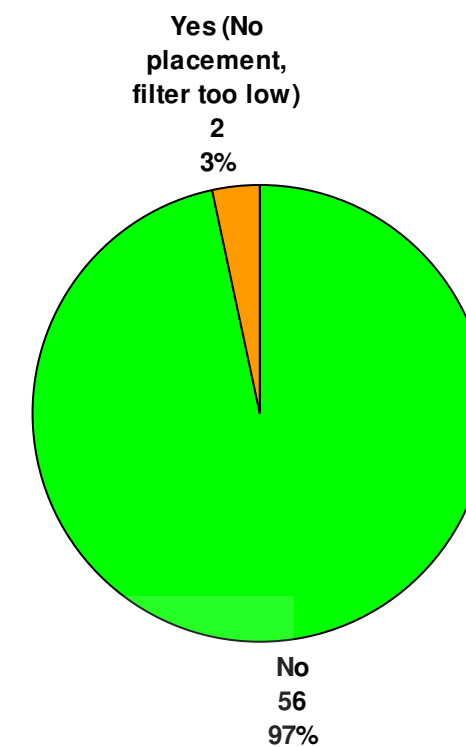


Fig. 3.55 Have you experienced any stability problems?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.55). Two households (3% of respondents) stated that they had a problem with the stability of the Filtron filter. However, the reasons for the instability did not concern the stability of the unit, but rather the instability of the surface where the filter was placed (fig. 3.56). One interviewee stated that stability problems had been experienced due to the fact that they had no specific position to place the filter unit, and the other stated that the filter was placed too low. This second statement does not relate to stability and could be the result of the interviewee misunderstanding the question.

3.4.2.2 (c) How do you lift the lid?



Fig.3.56 Filter placed on an unstable surface

Design implications

The improved filter should be equally or more stable than the Filtron filter. The filter should not depend on any other surfaces within the households and should not be able to be knocked over easily. If the filter unit is freestanding it must not rock or sway due to an uneven floor. One possible solution can be a support stand with three legs, as a tripod form always rests firmly on a surface, regardless of any surface deviations. However, other placement solutions must be explored.

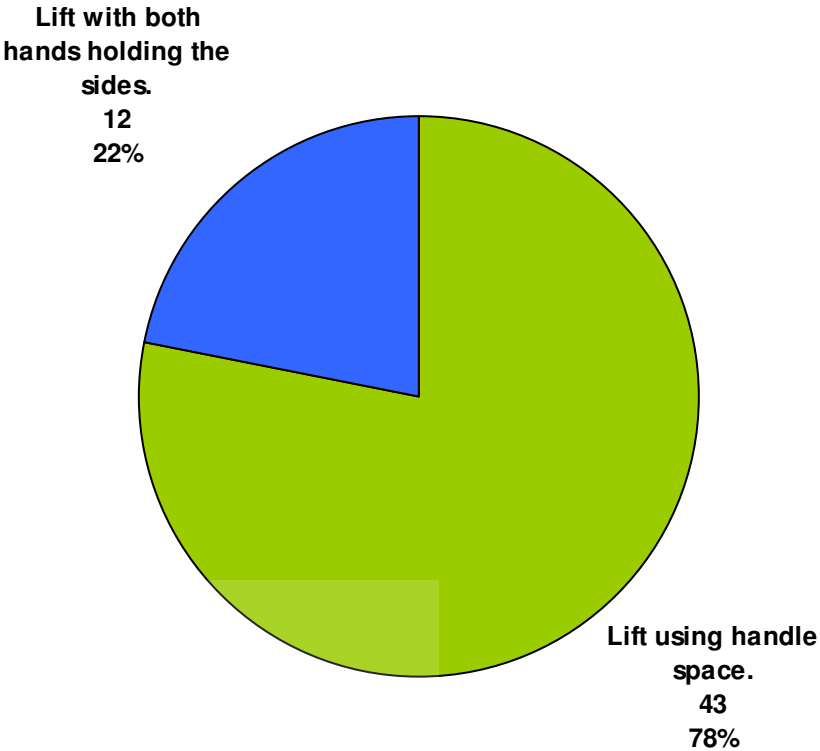


Fig. 3.57 How do you lift the lid?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.57). Although the covering lid of the Filtron filter has an incorporated handle (fig. 3.58), approximately one quarter of the users stated that they did not use it to lift the lid (twelve households, making up 22% of the sample group). The lid is lifted with both hands, taking hold of the lid by the edges on opposite sides. The remaining 78% of the users use the incorporated handle.



Fig.3.58 Incorporated lifting handle

Design implications

The improved filter design should be suited to be lifted in a variety of ways. It should include an incorporated lifting handle, and allow for easy grasping and lifting by its edges or sides. According to Tilley in *The Measure of Man and Woman*, hand grips should conform to use and hand motion and should be comfortable. Thin handles should be avoided as they cut under heavy loading (Tilley, 1993:74).

3.4.2.2 (d) Do you use a specific container for retrieving water from the spigot?

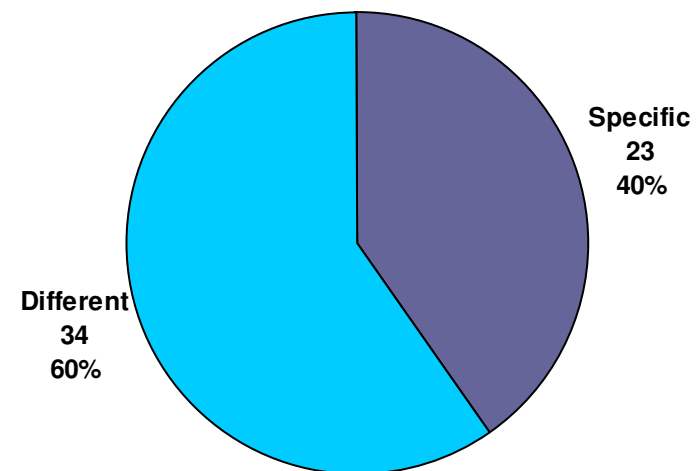


Fig. 3.59 Do you use a specific container or not?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.59). Twenty three users (40% of respondents) use a specific container for collecting water from the filter, such as a mug, teacup, small glass, jug, or a small pot/plastic bucket (fig. 3.60). The remaining 34 users (60% of respondents) use any available container that is clean.

Design implications

The improved filter should be suited to supply water to various types of containers, from a small teacup or glass, to small plastic buckets and jugs holding approximately two litres. Therefore, the improved filter needs suitable room underneath the spigot for the varying container types.



Fig.3.60 Different containers used for retrieving water from filter

3.4.2.2 (e) How do you place/hold the container and open the tap?

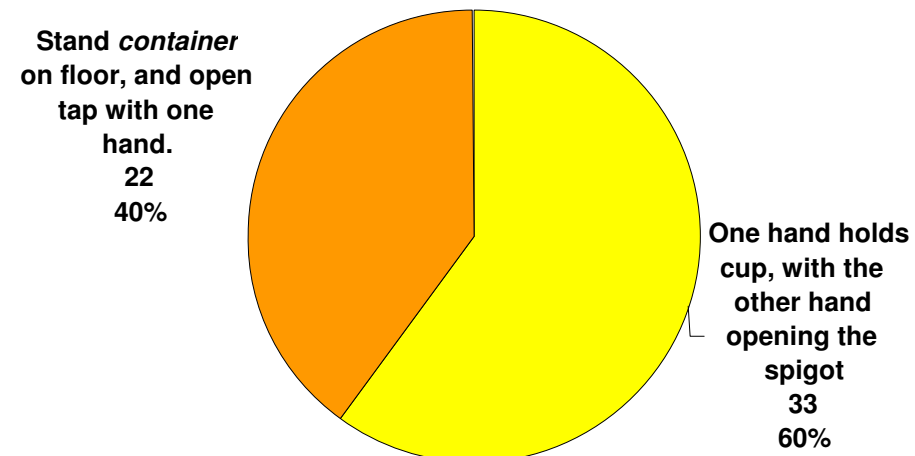


Fig. 3.61 How do you hold the container and open the tap?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.61). The disadvantage of placing the filter very close to the floor is that the user has to bend over to retrieve water. However, with the filter near to the floor, it makes it possible for users to place the container into which they wish to tap water directly on the floor and lock the spigot to the open position (fig. 3.62).



Fig.3.62 Container placed on the floor and spigot locked to an open position

This eliminates the need for the user to hold the container while it fills. Twenty two of the users (40% of respondents) retrieved water in this manner. The remaining 33 households (60% of respondents) held the cup underneath the spigot and operated the spigot lever with the remaining hand (fig. 3.63).



Fig.3.63 Container held underneath spigot and tap operated by user

Design implications

The spigot of the improved filter should ideally be operated in the same manner as the spigot of the existing Filtron filter, i.e. opened temporarily as well as locked to an open position providing constant water flow.

3.4.2.2 (f) Are any parts of the filter broken or damaged? If so, what parts?

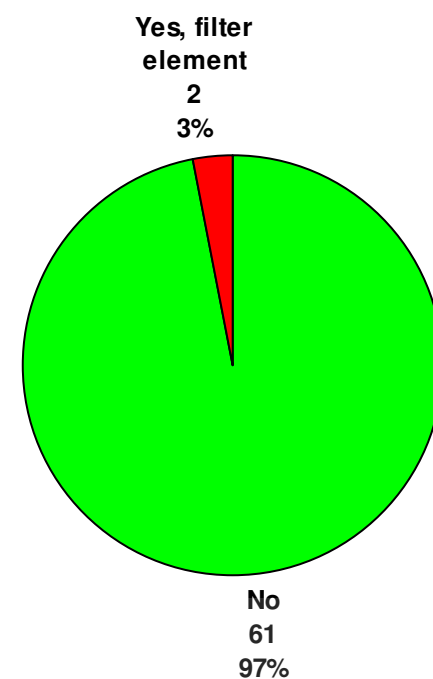


Fig. 3.64 Are any parts of the filter broken or damaged? If so, what parts?



Fig. 3.65 Slightly damaged filter element

Analysis

The analysed data has been presented visually in the figure above (fig. 3.64). Of all the households that responded, only two households (3% of respondents) reported breakages. In both instances, it was the filter element that got damaged. The one household's filter rim was slightly damaged (fig. 3.65). However, the filter was still functioning and filtered water effectively. In the other case, the filter element was lifted by a child and dropped by accident. This caused it to break into several pieces, ending the household's use of the filter (fig. 3.66). The filter element is the most fragile component in the entire filter assembly, and there are strict guidelines for caring and cleaning thereof (annexure 3). With 97% of the sample group having had no breakages, it indicates that the components of the existing Filtron filter are of a high quality, and that users looked after the filters' components. With regard to the filter element, the existing Filtron ceramic filter element is long lasting and effective although fragile. Breakage only occurred due to mishandling and not as a result of a filter design defect.



Fig. 3.66 Broken filter element

Design implications

If instructions for use and cleaning are correctly followed, the Filtron filter element is adequate, and design alterations are unnecessary. If the improved filter were to be knocked over, the ceramic element may break if lifted incorrectly, knocked over or dropped. For this reason, the improved filter must protect the filter element, and allow for it to easily be removed from the filter assembly. Users need to be informed about the importance of lifting the element with both hands, and to handle the filter element with care. This can be done by including a diagram sheet or maintenance manual with the filter unit. The ceramic element would need to be protected during transportation to the spaza shops, as well as transportation between the spaza shops and the households. The current spigot on the Filtron filter is of a high quality and is effective. It is therefore suitable to include the existing spigot type in the improved water filter design.

3.4.2.2 (g) Where is the Filtron filter located in relation to stored water?

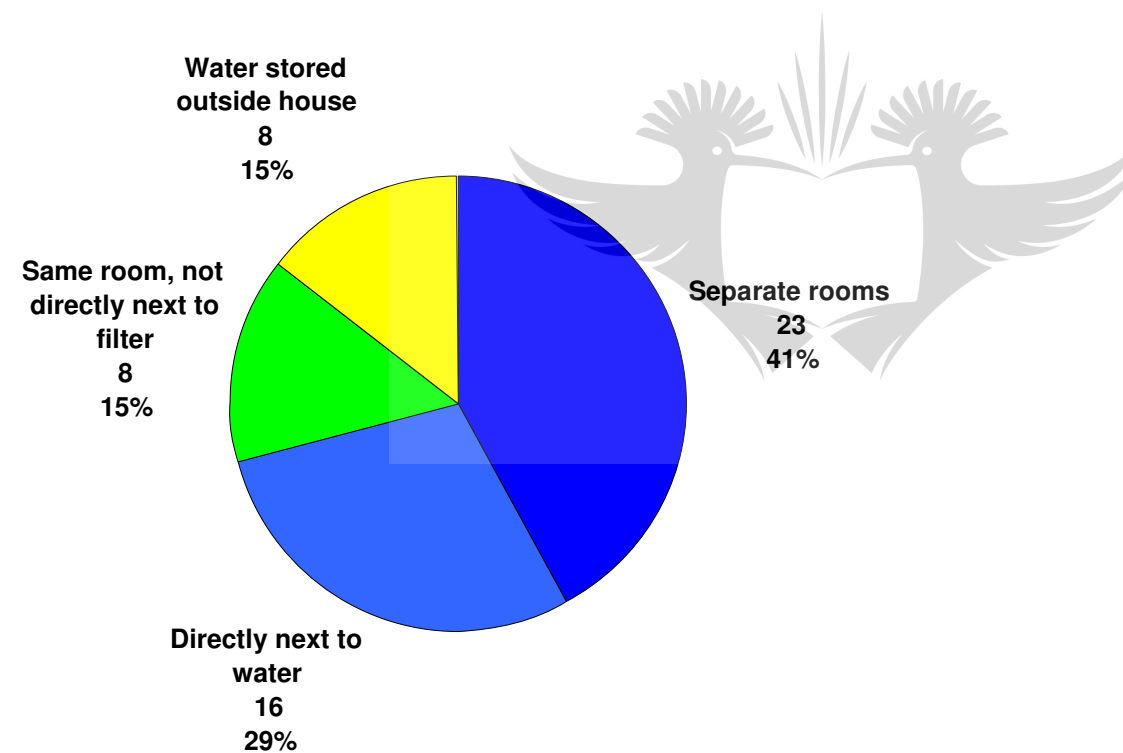


Fig. 3.67 Where is the Filtron filter located in relation to stored water?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.67). 24 households (44% of respondents) stored water (prior to filtration) in the same room as their filter (fig. 3.68 & 3.69). The remaining 31 households (56% of respondents) stored their water in another area of the house. This implies that every time the user wanted to fill the filter he/she was required to

go to the water storage area, fetch the water container and go back to the room where the filter was kept. He/she then filled the filter and returned the water container to the other room. Lifting and transporting water containers back and forth within the household may prove to be frustrating for users, as the nearer the container is to the filter, the more convenient. Twenty nine percent of the households had their water container directly next to the filter.



Fig. 3.68: Unfiltered water stored directly next to Filtron filter



Fig. 3.69 Unfiltered water stored in the same room as the Filtron filter

It would be beneficial if the water container were directly next to the filter. However, it depends on the user to decide where he/she keeps the water. Some households store water in large plastic barrels outside the house.

Design implications

It could be proposed that users should store their water which is to be filtered, near to the filter. This would minimise the effort required to fill the filter element. Furthermore, alternative methods of filling should be explored, for example siphoning or pumping water from the water container into the filter, preventing the user from having to lift an entire water container to fill the filter.

3.4.2.2 (h) Have any alterations been made to the Filtron filter?

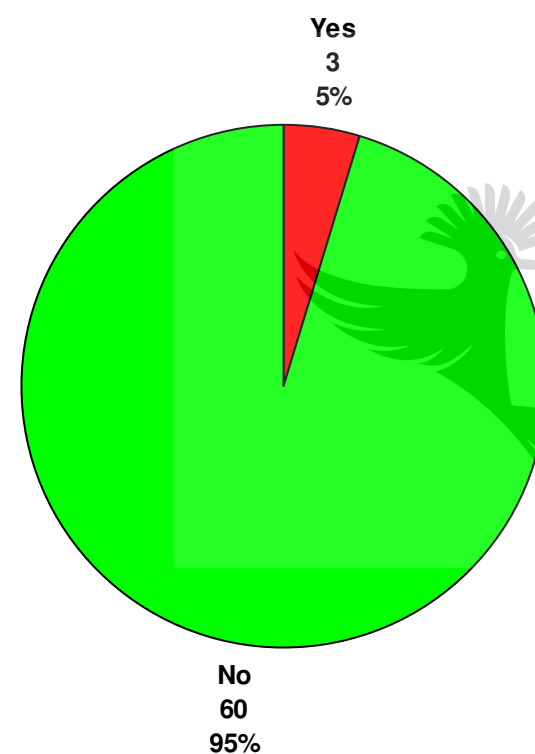


Fig. 3.70 Have any alterations been made to the Filtron filter?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.70). Only three households have altered the water filter. The remaining 60 filters are as they were upon implementation. One household altered the filter to maintain it (running maintenance). The filter's spigot began leaking water. This was repaired by wrapping a strip of plastic from a shopping bag around the spigot between the sealing washer and the receptacle (fig. 3.71).

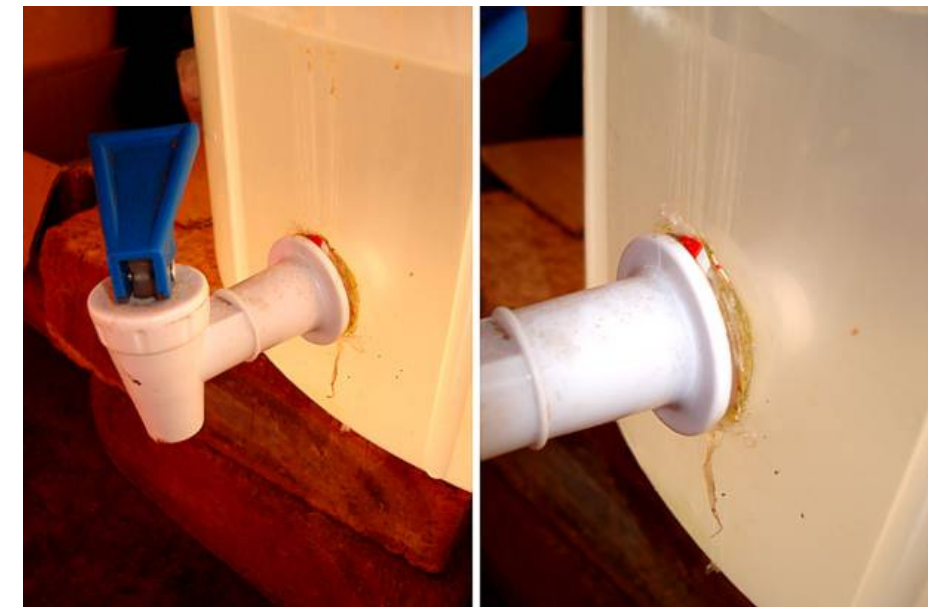


Fig. 3.71 Spigot repair using part of a plastic bag

The remaining two filters were not altered to maintain use, but their primary function as a water treatment device was altered. The use of the one household's receptacle changed from storing filtered water, to storing flour. The use of the ceramic filter element changed from filtering contaminated water, to storing sundry household items and is now a centre piece on the dining room table (fig. 3.72). The last filter receptacle is not used for water filtration, but for storing water that is scooped out when needed.



Fig. 3.72 Filter element used as a storage vessel for sundry household items

Design implications

A comprehensive training program needs to be in place to educate users on the correct assembly, use and cleaning procedures of the filters. The filter components must be of a high quality, allowing for a reliable product. The spigot, once assembled, must not allow for any filtered water to leak from the filter unit. Furthermore, the form and construction of the improved filter should afford other functions once it is no longer used as a water filter (filter element - flower pot/storage pot; receptacle - storage vessel). This is explained in the principle of behaviour shaping constraints by Kim Vicente in *The Human Factor* (2006:99) where every object has limited possibilities for action: "...you can do some things with it, but not others". Thus the object can be said to be *shape behavioural*. Vicente explains this with the example of a chair, that can be used to sit on, as well as a surface to stand on to paint the ceiling and also used to make a fire to prevent dying from cold. However, the chair cannot be used to fly (Vicente, 2006:99). Similarly, the form of the improved filter components can afford various uses, far removed from treating water on a microbial scale. These uses are illustrated by means of several photographs of other objects observed in the visited households. These include: storage of household items (fig. 3.73), storage of food items (fruit/ vegetables), as a pot for plants (fig. 3.74), or a pot stand for hot pots just to mention a few.



Fig. 3.73 Cardboard KIC packaging utilised by a rural household as a storage solution for multiple household items



Fig. 3.74 Plastic container no longer used for storing water

3.4.2.3 Analysis of use

3.4.2.3 (a) Is there a difference in the taste of the filtered water?

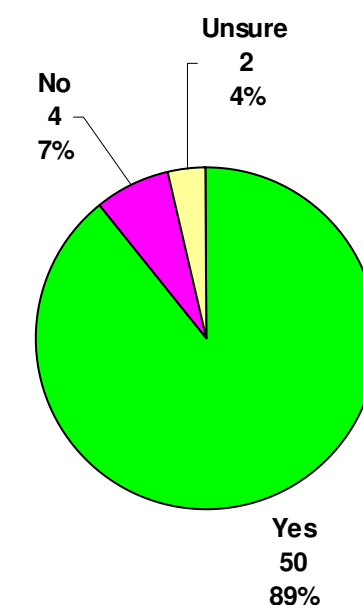


Fig. 3.75 Is there a difference in the taste of the filtered water?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.75). Approximately 90% of the sample group noted that there was a difference in the taste of filtered as opposed to unfiltered water.



Fig. 3.76 Filter user sips filtered water from a designated drinking container

Design implications

The current Filtron filter filters the water on a microbial level, removing contaminants. However, the users noticed that there is difference in the taste of the water. If the improved filter alters the taste of the water, it must do so in a positive regard.

3.4.2.3 (b) Do you like the taste of filtered water?

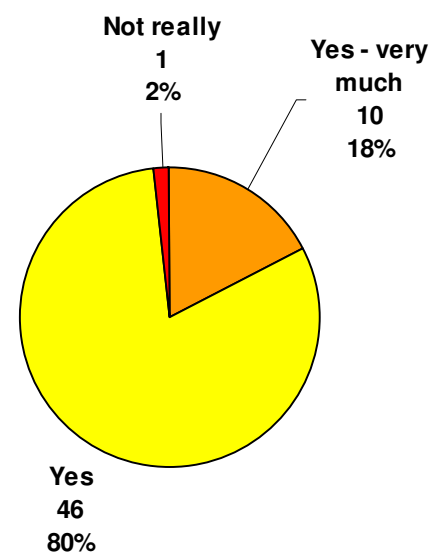


Fig. 3.77 Do you like the taste of filtered water?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.77). Only one household stated that they did not really like the taste of filtered water. The remaining 56 liked the taste of the water, with 18% liking the taste very much (fig. 3.74).

Design implications

If users enjoy the taste of the filtered water, they are more likely to use persistently use the filter. The improved filter should therefore improve the palatability of the water as far as possible.

3.4.2.3 (c) How many times do you fill the filter per day?

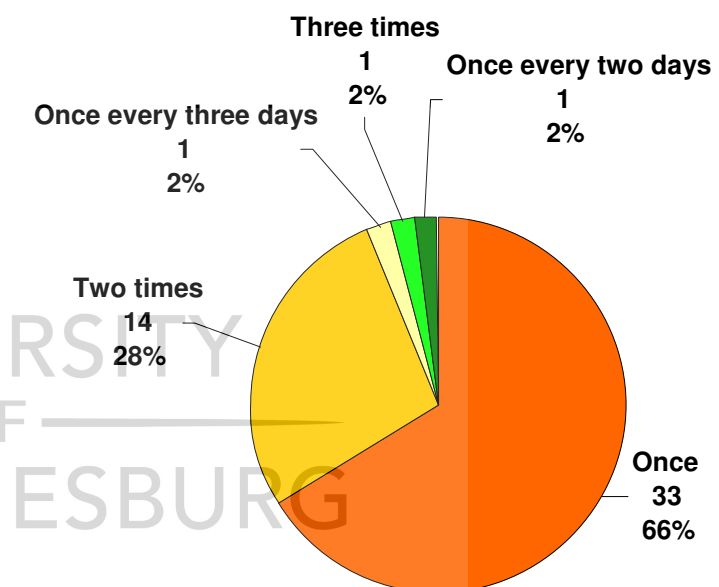


Fig. 3.78 How many times do you fill the filter per day?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.78). Households fill the filter element at least once per day. Most (66% of respondents) claim that they fill it only once per day, with the most fills being three times a day (2% of respondents).

Design implications

The filter will need to be filled at least once a day, however, this depends on family size and amount of water being consumed. For a family size of four, receptacle volume should contain a maximum volume of 16 litres to suit a daily two litre consumption per person. Whatever covering lid system included in the improved filter design must be easy to operate. Innovative

uses of the covering solution must be explored, for example, possibly to be used as a container to decant water into the filter element.

3.4.2.3 (d) How do you fill the ceramic filter? (scooping from drum, pouring from large bottle, etc.)

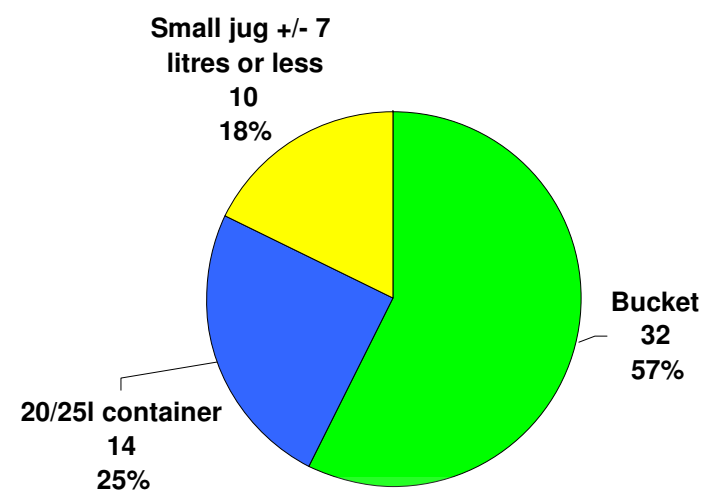


Fig. 3.79 How do you fill the ceramic filter?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.79). 14 households (25% of respondents) filled their filters directly by pouring from a 20/25 litre container (fig. 3.80). This container weighs between 20 and 25 kg when full and can create a lot of strain to the person lifting it, especially if not lifted carefully. Due to the fact that users fill the improved filter by using 20/25 litre containers, the observation was made that the filter should ideally be at a low enough height to prevent unnecessary strain on the users.



Fig. 3.80 Twenty five litre containers used for storing unfiltered water

Forty two households decant water from a larger container (in most instances, a large plastic bucket or barrel), using a plastic bucket or small jug (fig. 3.81 shows the filter, yellow decanting jug, and blue plastic barrel containing unfiltered water). The bucket or jug is easier to lift and weighs much less than a large water container.



Fig. 3.81 Users decant water from a blue plastic barrel into the Filtron filter using plastic jug

Design implications

The improved filter could possibly incorporate a vessel for decanting water into the filter. This would provide users with an alternative solution other than lifting and pouring from heavy water containers, if they do not have a suitable decanting container. The improved water filter must be easy to be filled. The filter should ideally be at a suitable height for a user to comfortably pour water from a 25 litre container. Alternatively, this method of filling could be substituted by considering an innovative approach to supplying the filter with unfiltered water, by means of the possible incorporation of a decanting vessel for filling the filter.

3.4.2.3 (e) Is the Filtron filter in operation?

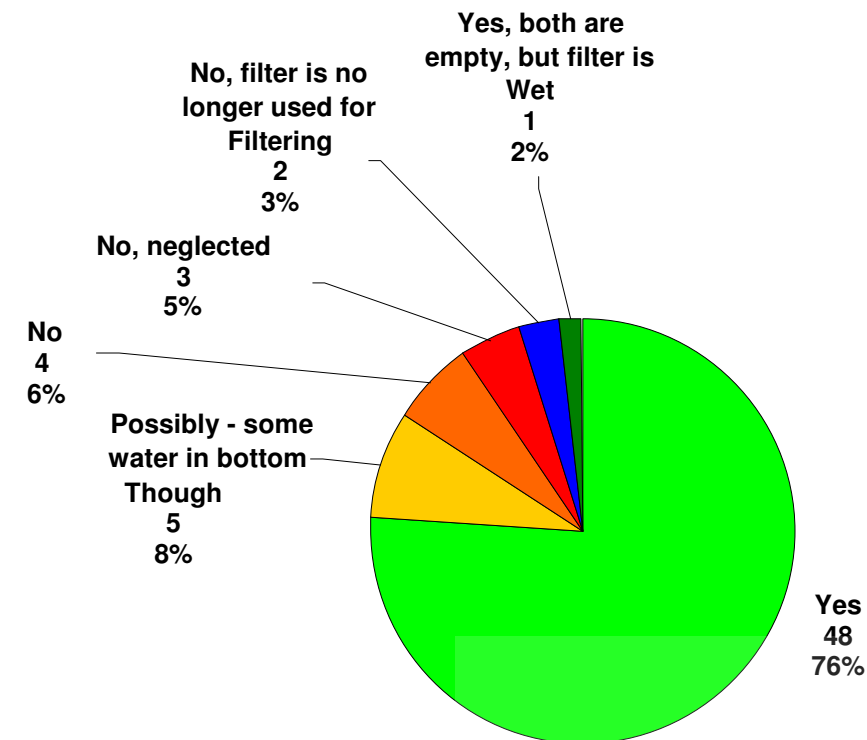


Fig. 3.82 Is the Filtron filter in operation?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.82). 48 households (76% of respondents) were still using the water filter for filtering water. Three households (5% of respondents) neglected the Filtron filter by leaving water inside, allowing insects to inhabit the filter and contaminate it (fig. 3.83).



Fig. 3.83 Neglected filter receptacle containing water and insects

Five households (8% of respondents) were not using the filter at the time, although the filter receptacle was wet. Two households did not use the filter for filtering but for other functions such as water storage and flour storage (fig. 3.84).



Fig. 3.84 Filter receptacle used for flour storage

Design implications

The components of the improved filter design must be easy to clean. This is due to the fact that dust, mud, algae and other dirt may collect on the filters components. The components must be able to offer other functions beyond the initial intended function.

3.4.2.3 (f) Fig. 3.82 Are there any insects present underneath the lid?

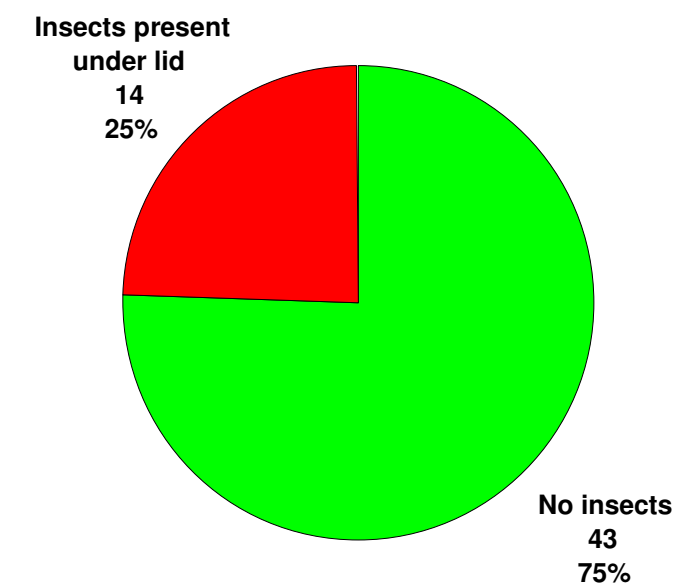


Fig. 3.85 Are there any insects present underneath the lid?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.85). 14 households had insects underneath the covering lid (25% of respondents). The moisture under the lid makes for a habitable environment for the insects (fig. 3.86).



Fig. 3.86 Condensation under the covering lid attracts insects

This is a problem as insects are considered to be a possible source of microbial contamination (Gundry et al, 2006:7). The covering lid of the Filtron filter does not fit tightly onto the filter retaining ring, thus allowing insects to gain access to the inside of the filter (fig. 3.87).



Fig. 3.87 Insects on the filter retaining ring

If the filter does not fit snugly into the filter retaining ring it makes it possible for the insects to move into the lower receptacle, creating the possibility of contaminating the filtered water.

Design implications

It is necessary that the improved filter should have a covering lid that does not allow insects to access. This covering lid must be easy to use. It must easily locate/assemble onto the filter assembly without any complications or confusion.

3.4.2.3 (g) Do you experience any problems when filling the filter?

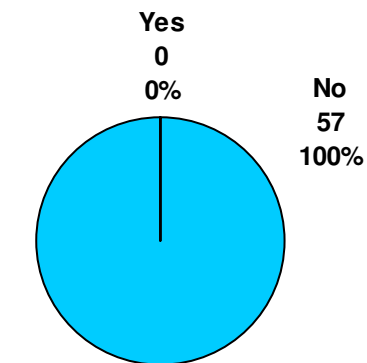


Fig. 3.88 Do you experience any problems when filling the filter?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.88). None of the users had experienced problems with filling the filter. Therefore, the loose fitting covering lid is a suitable covering system (fig. 3.86). Users stated that the filter was at a comfortable height for filling, and the Filtron filter suits being filled from a variety of different water container types (25 litre water containers, and decanting from large 200 litre plastic drums using various jugs or cups).



Fig. 3.89 The loose fitting covering lid is easy to operate

Design implications

The covering lid must not obstruct the filter element during the filling action. Furthermore, value can be added to the covering lid through the inclusion of innovative design aspects in the covering lid form. For example the lid could be used as a container to fill the element; it could include a hanging hook allowing it to hang on the receptacle; it could be used as a container in which household items can be stored if the filter is no longer needed for filtration.

3.4.2.3 (h) Do you experience any problems or irritations when cleaning the ceramic filter?

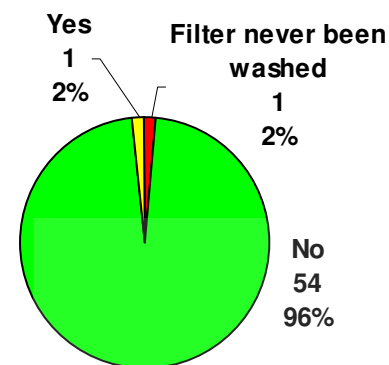


Fig. 3.90 Do you experience any problems or irritations with cleaning the ceramic filter?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.90). Almost the entire sample group (96% of respondents) experienced no problems when cleaning the ceramic filter. The required maintenance tasks are therefore not a strain on the users. One household had not washed the filter. This makes it evident that although users may have been educated on correct usage, there was no guarantee that they would follow instructions.

Design implications

Cleaning instructions for the filter element components must be supplied with the filter unit. These should be in a pictogram form making it possible for people who are illiterate to understand the instructions. Any written components or headings should ideally be in the home Language of the user as well as the English language. This suggestion considers the fact that that primary school children within households speak Venda as a home language and study English as one of the subjects at primary school.

3.4.2.3 (i) Does the filter's tap leak water?

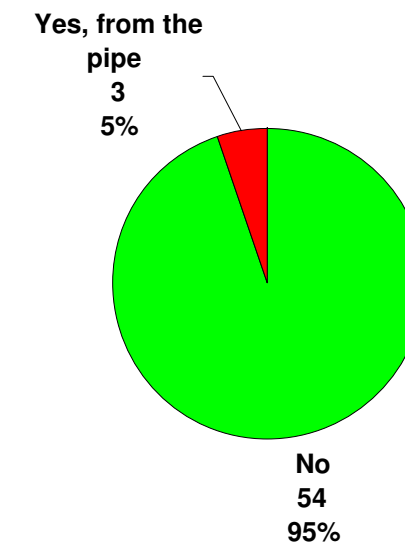


Fig. 3.91 Does the filter's tap leak water?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.91). During implementation, leakages occurred from the spigot in several instances (fig. 3.92). The leakages were eliminated by ensuring that the spigot retaining nut was correctly tightened. One household repaired a leaky spigot by using of a strip of plastic from a grocery bag (fig. 3.71). More than 95% of the households experienced no instances of leakage during several months' use of the filter.



Fig. 3.92 Leaking spigot problem corrected by tightening the spigot retaining nut

Design implications

The spigot of the Filtron filter is adequate. It is a standard component that fits through a hole in the receptacle wall. Re-designing this component is unnecessary as it functions effectively. Although the spigot is effective and successful in the Filtron filter, alternative methods of retrieving water from the filter should be explored. Assembly instructions need to be clear and easily understood to prevent leakage from the spigot due to an under tightened retaining nut.

3.4.2.3 (j) Does the filter's tap supply water fast enough?

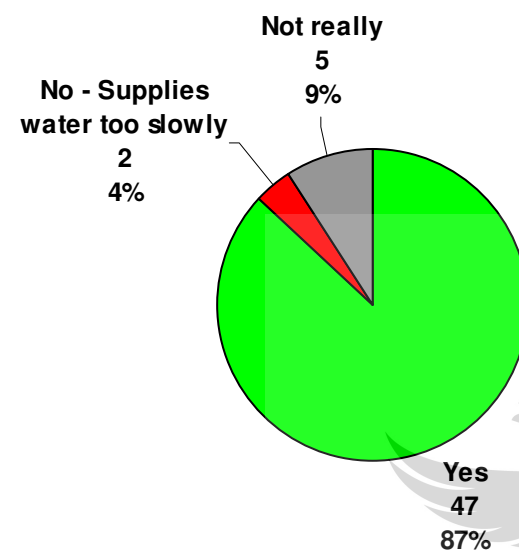


Fig. 3.93 Does the filter's tap supply water fast enough?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.93). Forty seven households (87% of respondents) had no problem with the supply rate of the spigot. The current spigot supplies water at a suitable rate. An alternative spigot with a higher supply rate is therefore unnecessary. The spigot must supply water at a rate which the users accept. If the spigot supplies water very slowly, the users may become frustrated. This may cause the users to discontinue use of the filter unit.

Design implications

Alternative spigot solutions such as alternative tap types can be explored. The supply rate of the spigot must suit the user's needs.

3.4.2.3 (k) Does the filter provide sufficient water for everyone in your family?

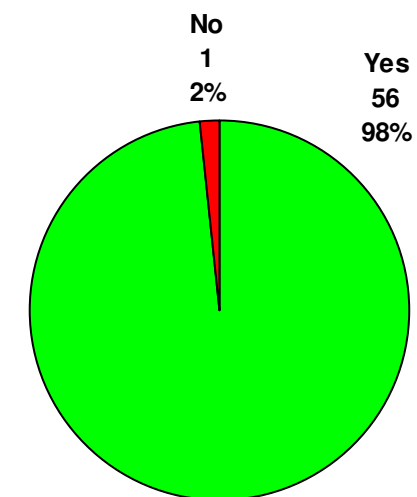


Fig. 3.94 Does the filter provide sufficient water for everyone in your family?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.94). Fifty six households (98% of respondents) stated that the filter supplied sufficient water (fig. 3.95). The receptacle can therefore hold sufficient water for the household. The filter also filters water at an acceptable rate, taking the diverse range of filtration rates of the filters into account.



Fig. 3.95 Ninety eight percent of the households stated that the filter supplies sufficient water

Design implications

Although the volume of the receptacle as well as the filtration rate of the filter is adequate, 48 households fill the ceramic filter once or twice per day (96% of respondents of previous survey, 3.4.2.3(c) on page 38). The receptacle should be able to store a maximum volume of approximately twice the filter volume. The receptacle can therefore decrease in size from the Filtron filter's receptacle (holding up to 40 litres) to a capacity of approximately 16 litres. This will decrease the size of the receptacle, and the amount of material used in the manufacturing process, therefore decreasing manufacturing costs and allowing unit costs to be as low as possible.



Fig. 3.97 Varying level of filter cleanliness: spigot

3.4.2.3 (I) Does the Filtron filter look clean?

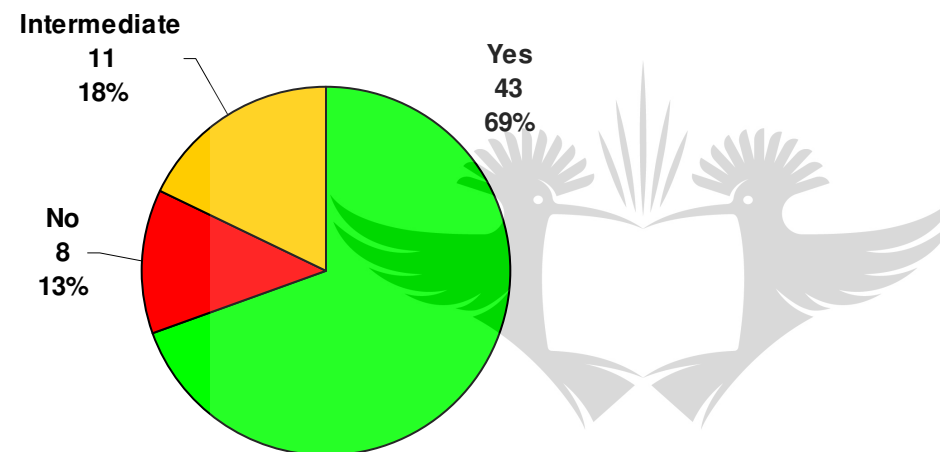


Fig. 3.96 Does the Filtron filter look clean?

Analysis

The analysed data has been presented visually in the figure above (fig. 3.96). The environment surrounding the villages is very sandy and dusty. Household items therefore become dusty relatively quickly. Approximately 70 % of the sample group had filters units that looked clean, and 18 % had filters units that were a little dusty. However, as dust can collect within hours of a surface being cleaned, it is not possible to say that these households neglected the filter unit. Thirteen percent of the group had filters that were not cleaned. This is evident by a build-up of dirt around the spigot (fig. 3.97) and in the rim of the lid (fig. 3.98).

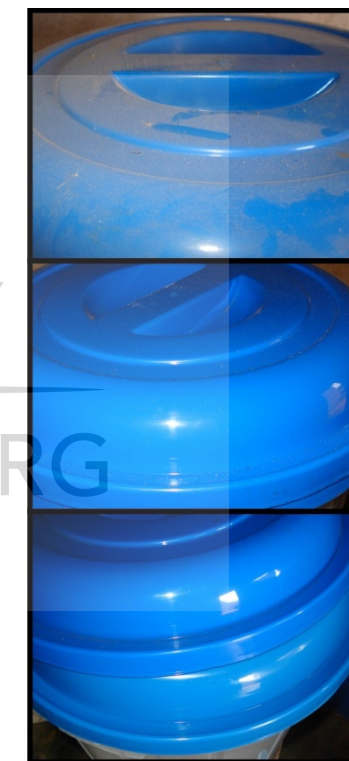


Fig. 3.98 Varying level of filter cleanliness: covering lid

Design implications

The filter should include a dust cover or covering lid to prevent dirt from collecting in the element. The filter should be as easy to clean as possible, therefore containing a minimum of unnecessary dirt traps. However, the rigidity of the plastic and ultimately the accuracy of positioning the lid relies on bends in the plastic in the form of ridges, ribs and beads (fig. 3.99). These forms in the lid and retaining rings of the Filtron filter create areas where dust could collect (fig. 3.99 & 3.100).

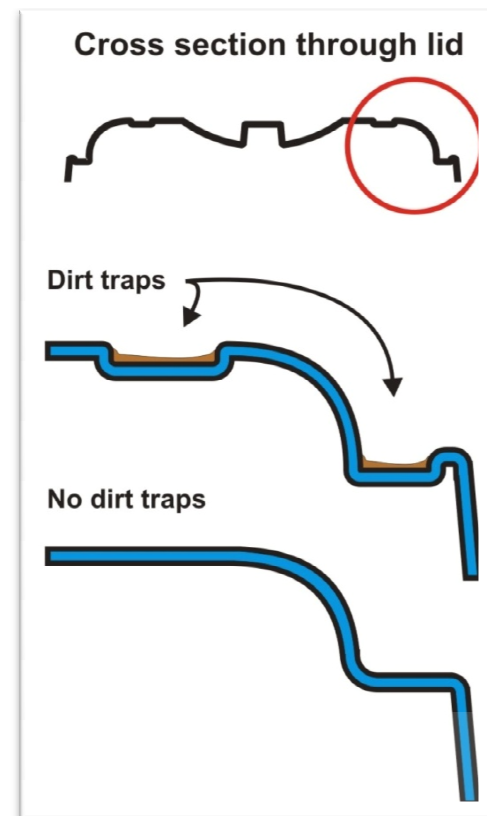


Fig. 3.99 Dirt traps



Fig.3.100 Dust/dirt trap on the filter covering lid

If the form were altered to eliminate dust traps, the rigidity of the filter could be compromised, allowing the lid to deform after moulding. A compromise must be found between rigidity and dirt traps.

3.4.2.3 (m) What can be changed on the filter to make it easier to use? (comments by community members)

Users were asked their personal opinion about what could be changed or altered to make the filter easier to use. Households were willing to provide their input in the form of suggestions to better the filter design, making it more suited to their needs and preferences. Of 58 households, 37 households (64% of respondents) said that nothing should be changed to improve the filter usage, four households (7% of respondents) were unsure of any possible areas of improvement, and the opinions of the remaining 17 households (29% of respondents) are as below. Opinions have been divided into **viable** and **non viable** to be considered during the design process. Descriptions as to why a point has been classified as **viable** or **not viable** are included with each point.

Viable:

- Elevate the surface where the filter is placed/provide a stand to allow for easier access (six instances: 10% of all households).
 - The stand can be incorporated into the design, or be supplied with the filter unit.
- The filter element should have incorporated handles to make lifting easier (one instance: 1.7% of all households).
 - This is possible due to the properties of the ceramic used in the filter element manufacturing process.
- Include a stand on which the filter can rest while it is being cleaned because the surfaces within the households collect dust and dirt very easily (one instance).
 - This can be incorporated into one of the other components comprising the improved filter design.
- Design a system to prevent cockroaches and ants from entering the filter because the existing filter allows for insects to enter (one instance).
 - This has become evident in the field visits, and can be solved by a covering lid preventing insects from entering the filter.

Non viable:

- Container should also cool water, using electricity, to make the water more enjoyable.
 - If electrical components are included in the improved filter, it will increase the cost of the filter (one instance). If the receptacle were made from ceramic instead of plastic, the water could be cooled through evaporation.

- Increase the size of the filter element to allow for more water to be filtered (two instances: 3.5% of all households).
 - This is not viable. According to other statistical findings, 98% of the sample group stated that the filter provided sufficient water.
- If the filter element were plastic, it would be less fragile and lighter. This would make it easier to be lifted and carried by children (two instances).
 - This is not possible, as the filter element is made of ceramic, due to its suitable characteristics allowing it to be used as a filter together with the added effectiveness of colloidal silver. Plastic does not have suitable characteristics and can therefore not be used for the filter element.
- Increase the container volume (four instances: 7% of all households). Volume increase from 40 litres to 120 litres to provide users the opportunity to sell water.
 - This contradicts design solutions as summarised under the previous point: Does the filter provide sufficient water for everyone in your family? However, this could provide opportunity for developing similar products in the future, able to supply a larger volume of water.

3.4.2.4 Spaza shop visits

If the filter were to be distributed, it would need to be stocked in resale outlets near to where the intended users live. These retail outlets would be the spaza shops, or building supply/hardware stores within the rural areas. For this reason, seven spaza shops were visited in seven villages within the Vhembe area. These shops were visited to gain an understanding of the types of products available, as well as the sizes of those products. The available space within these shops was also noted. The purpose of this was to observe how much space would be available within the spaza shops where the improved filter could be stocked. If the filter units were to be stocked at building supply/hardware stores, the store may be able to deliver the units to the user's houses, or to the various spaza shops distributed throughout the rural areas. This would allow for an effective distribution channel between manufacturer, building supply/hardware store, spaza shops and rural household.

Are there other products similar in form and size to the Filtron filter?

Yes: (three instances) – fig. 3.101

No: (two instances) – fig. 3.102

No, but there is ample room. (one instance)

Although there are no existing water filters for sale at any of the spaza shops, most have the available room to stock items.



Fig. 3.101 Plastic products on fridges are similarly sized to the Filtron filter



Fig. 3.102 Small spaza shop stocks no products similarly sized to Filtron filter

If the improved filter were to be stocked in shelving space/shop space, where would be suitable, and what dimensions would be available?

Where would be suitable? (table 4)

On top shelving – fig. 3.104

On top of Coca-Cola fridges – fig. 3.101

In shelving

On palette – fig. 3.103

On floor (under shelf)



Fig. 3.103 Spaza shop has ample room to stock filter components



Fig. 3.104 Filter components could possibly stack on top shelf

Table 4. Dimensions of available spaza shop storage space

| Where is suitable? | Width (mm) | Height (mm) | Depth (mm) |
|---------------------|--------------|-------------|------------|
| On top shelf | 1200 | 800 | 400 |
| On top shelf | Shop length | 450 | 450 |
| On Coca-Cola fridge | 1800 | 700 | 700 |
| In shelving | 750 | 400 | 400 |
| On palette | 1000 | unlimited | 1000 |
| On palette | 1200 | unlimited | 1200 |
| Floor (under shelf) | 800 | 700 | 300 |
| Floor (under shelf) | 500 | 900 | 600 |
| Floor (under shelf) | whole length | 450 | 450 |
| Floor (under shelf) | 1300 | 600 | 600 |
| Floor | 600 | 2000 | 600 |

Analysis

In general spaza shops have limited space.

Design implications

Filter components should take up as little space as possible. This can be done by designing components to be stackable, flat packable, or to nest effectively within each other. It is beneficial for transportation and shipping.

For water filters to be accessible to households in rural areas, the units would need to be available at resale points within the rural areas, this includes spaza shops and building supply/hardware stores. The water filter therefore needs to be transported easily from the manufacturer to the shop where it will be stocked. Similarly, the filter needs to be carried to the households and can therefore not be cumbersome. The filter components need to stack in a manner suited to shops, as these shops have a limited amount of space and will possibly refuse to stock water filters if units take up a large amount of shop space. If the filter could be stocked in the smaller spaza shops, it will be easy to fit into other, larger retail stores in rural areas, such as building supply/hardware stores. The more readily available the improved water filter, the more likely users will be to purchase it. For this to occur, consideration of the product's distribution channel (from point-of-manufacture to point-of-resale) needs to be included in the design. This will make both stocking in the spaza shops and transportation and shipping possible. Ergonomic considerations must be taken into account with regard to transporting the filter units to the households.

3.4.2.5 Potter visits

As the filter element is manufactured out of a ceramic material, manufacture of these elements may possibly be carried out by local potters within the Vhembe region, using local clay. Visits to these potters were conducted to observe the clay manufacturing methods currently in practice. The potters sourced clay from nearby riverbeds. Once items were shaped, they were air-dried and then fired in either open fires or a kiln (fig. 3.105).



Fig. 3.105 Potters in the Vhembe region preparing clay before shaping it into various products

It is evident that existing clay resources in the rural areas allow for the possible manufacturing of the ceramic filters at a community or household level. Due to the ceramic filter's shape, it can be manufactured by hand. However, the number of units produced would be relatively low, due to manual intensity, compared to the numbers produced if a press-form mould were available. The designs of the press-form mould are readily available on the Potters For Peace website and no power or fuel is needed in the operation (annexure 21). Furthermore, with Limpopo's wealth of natural resources excellent manufacturing opportunities exist, one of which is brick manufacturing (SouthAfrica, 2008). The possibility exists to receive clay castoffs from the local brick manufacturers for use in manufacturing ceramic filter elements in the Limpopo province, thereby also providing local employment. Further research needs to be conducted regarding the suitability of the clay sourced and used by the local potters within the rural areas (fig. 3.105).

3.4.2.6 Personal observations

The following are points observed whilst conducting the observations within the rural households. From these observations, design implications have been included which in turn can inform the improved filter design.

3.4.2.6 (a) General trend of low water levels in receptacles

During the 65 household visits, it was observed that a considerable number of households filters contained very little, and in some cases no water in the receptacle. It seemed as though the households allowed for only a small amount of water to collect in the receptacle, indicating that more training regarding filter use and management would be required (fig. 3.106).



Fig. 3.106 Low level of filtered water in the receptacle

Analysis

It seemed as though users filled the filter element (fig. 3.107, 1), waited for that water to filter into the receptacle (fig. 3.107, 2), and then used the filtered water before refilling the filter element (fig. 3.107, 3).

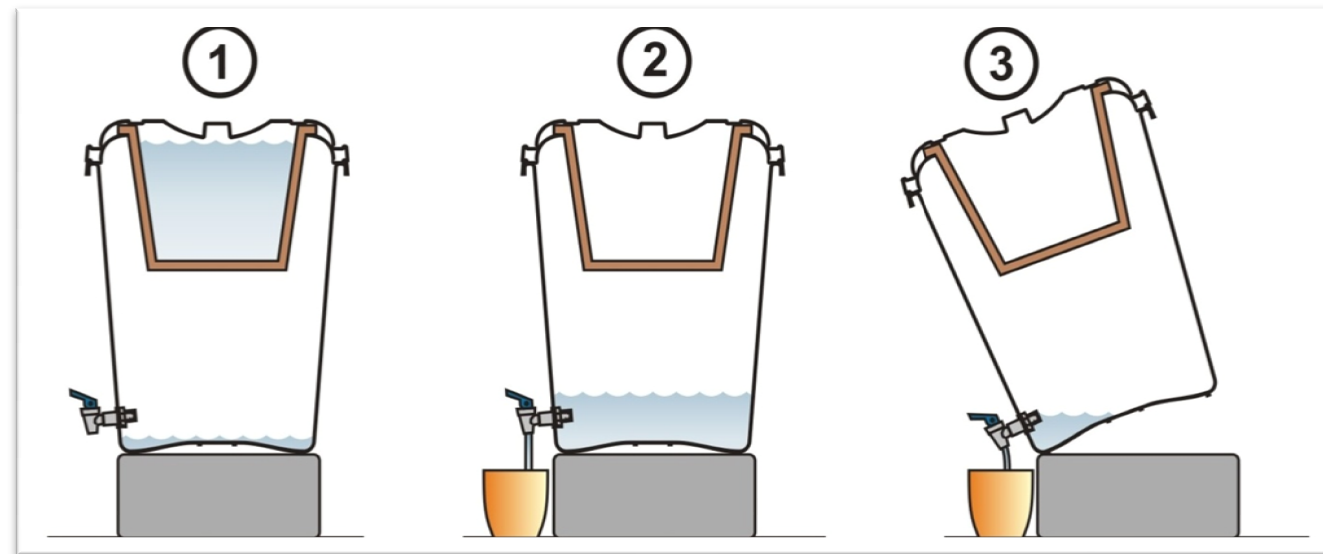


Fig. 3.107 Water retrieval from the receptacle

This implies that households only used eight litres of the receptacle's 40 litre capacity. This could create a chance of households reverting to using unfiltered water, should the receptacle run out of water. Frustration results when a user is attempting to retrieve water from the filter by having to tilt the unit to retrieve the water (fig. 3.107, 2). Furthermore, the higher the level of water in the receptacle, the more pressure is applied, forcing water from the spigot, in turn improving the flow-rate. If the water level were kept higher, the above would not be a problem.

Design implications

One way of informing the users of a suitable water level could be by incorporating a simple graphic onto the side of the receptacle, suggesting a "full" mark (fig. 3.108). Another possible solution is to include a pictogram in the leaflet, explaining how full the filter should be kept and suggestions for best practice.



Fig. 3.108 Possible graphic indicating "full" mark

3.4.2.6 (b) A part of the rim of the receptacle can be mistaken as a lifting handle which proves un-ergonomic when used for lifting the receptacle.

Analysis

On the lip of the receptacle, there is a raised section of plastic into which a hole is drilled, presumably where a bucket handle could be assembled (fig. 3.109).



Fig. 3.109 Mistaken lifting handle proved un-ergonomic

This is because the 50 litre bucket moulding used for the receptacle is also used for other products manufactured by the plastic manufacturing company. However, this part of the moulding can easily be mistaken as a lifting handle for the receptacle because it is placed where one would normally find incorporated lifting handles. The feature has a vertical edge that

digs into one's fingers if the receptacle is lifted and proves un-ergonomic, more so, if the receptacle contains a considerable amount of water.

Design implications

The improved filter should be ergonomic to lift, inflicting little or no discomfort on the user. The improved filter should be purpose made, with all aspects of the design suited to its functions. Several existing standard components may be included in the improved filter design.

3.4.2.6 (c) When retrieving water, household does not understand that the spigot has two positions, temporary flow, and locked flow.

Analysis

Upon interviewing, it was discovered that one household did not know that the filter receptacle had two positions (fig. 3.110).

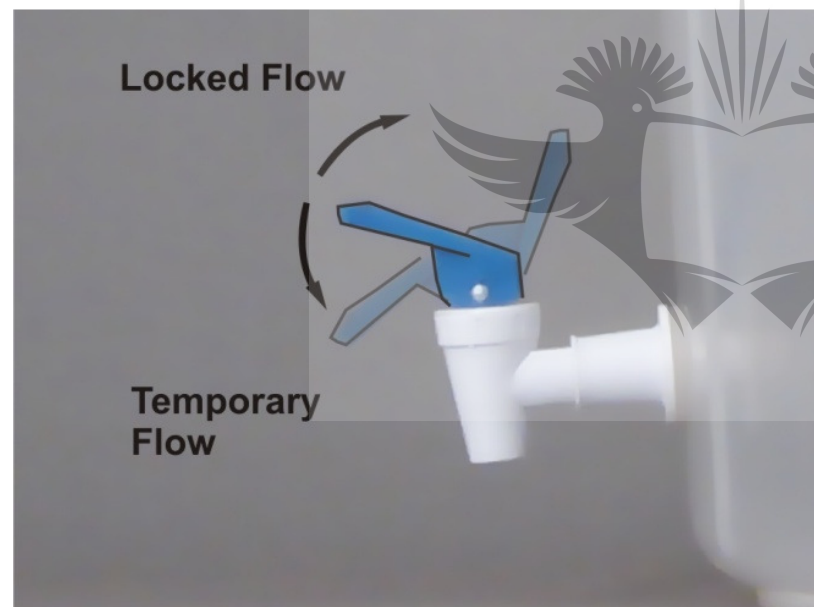


Fig. 3.110 The spigot has two positions: locked flow and temporary flow

This user would sit comfortably on the floor and manually hold the spigot in the open position when large amounts of filtered water were needed (fig. 3.111).



Fig. 3.111 Filter user sitting on floor, manually keeping spigot in temporary flow position

Design implications

This problem can be solved by including information regarding spigot use on the filter receptacle using a simple pictogram, or in the leaflet supplied with the filter. The users will be able to refer to the leaflet upon receiving the filter, as well as refer to the leaflet at a later date.

3.5 Synopsis

When analysing the gathered data, areas of improvement became apparent, as well as aspects of the Filtron filter that are successful. By relying on these possible points of improvement for designing the improved filter, the users involvement informs the design process. In the following chapter, a list of design requirements was compiled from the analysed data, around which the designing of the improved filter will take place. Each step of the design process is then described, culminating in the presentation of the improved filter design.

CHAPTER 4: DESIGN REQUIREMENTS FOR THE IMPROVED WATER FILTER, CONCEPTUALISATION, FINAL DESIGN

4.1 Introduction

When considering all the gathered data and proposed design solutions, I formulated a list of design requirements for the improved water filter. By satisfying these design requirements the problems that became evident during the field testing of the Filtron filter can be resolved. The design requirements not only focus on the negative aspects of the Filtron filter that became evident via the data gathering process, but also on the positive points of the existing filter.

An additional design problem not discussed in the user research is the affordability of water filters if households should purchase the units. The average income of households in the rural areas of South Africa is very low, being below R1 200 per month (Van Vuuren, 2007:19). The improved water filter would therefore need to cost a fraction of this amount. Alternatively, filters could be funded by Government or NGOs and implemented as part of the water management systems of rural areas, with households contributing a small amount towards the filter cost. The purchase or partial purchase of the filter unit could create a sense of ownership.

Replacement parts of filter components must be available in spaza shops, for users to carry out maintenance and repairs to the filters. These component prices need to follow similar funding principles as proposed above. Maintenance refers to replacing damaged or broken parts with new parts purchased from the spaza shop, not repairing broken parts. Whichever way the filter and replacement parts are distributed, the unit cost of each filter needs to be as low as possible. Therefore, suitable manufacturing methods need to be explored to find production methods and selection of materials that would yield components with a low cost-to-benefit ratio. In other words, the filter must function optimally with as low a cost impact as possible.

For the improved water filter to be sustainable, it should be developed to a level where it will continue to function and be used for a considerable amount of time without becoming obsolete.

Sustainability can be regarded as providing local employment and stimulate industry by utilising local community potters and materials. Another consideration for sustainability could be the design of new uses for the filter after it no longer functions effectively. For example, the ceramic filter element could be used as a flower pot, i.e. shape behavioural constraints (Vicente, 2006:99).

4.2 Design requirements

All the gathered data was summarised in a list of design requirements. The points were divided into three categories, high, medium and low priority.

4.2.1 High Priority: Primary design requirements: important to consider in the improved water filter. This also includes existing strong points of the Filtron filter requirements regarding considerations for manufacturing.

- The filter should be functionally suitable to be placed in the main rooms of the households, not only the kitchen. It could be placed in the kitchen as well as the bedroom, main room, lounge, or entrance room.
- The filter should either be used free standing, or must be able to be operated without relying on existing surfaces in the households. This would eliminate the need to find an existing placement surface in each household.
- If the filter relies on a stand, this stand must be provided as a portion of the filter unit/or incorporated into the filter.
- The filter could be used while resting on the floor.
- The filter must be placed at a suitable height to allow the user to retrieve water without having to bend over uncomfortably, as well as low enough to the floor to allow the user to comfortably fill the filter element, by using various water storage containers.
- The spigot should not be lower than 200 mm above floor level and not higher than 800 mm.
- The improved filter must be as stable as or more stable than the Filtron filter.
- On the improved filter, all areas where lifting and holding will occur, should be comfortable to hold.
- The filter must include a dust cover or covering lid to prevent dirt from coming into contact with the element.
- The covering lid must be easy to operate.
- The covering lid must remain open while the filter is being filled. Users may need two hands to lift the water filling container, leaving no hands free for holding the covering lid open.
- The covering lid of the filter must not allow access for insects into the filter.
- The filter should fit into the receptacle/retaining ring correctly, not creating a gap, allowing spilled water to bypass the filter element and run into the receptacle.

- The improved filter should be able to supply water to any type of container from a small teacup or glass, to small plastic buckets and jugs, holding approximately two litres.
- Users need to be informed of all procedures for caring and cleaning the improved filter. This should be done by including a pictogram sheet and maintenance manual with the filter unit.
- The filter receptacle capacity should be able to store sufficient filtered water. For an average household of four, the receptacle should store an optimum volume of twice the volume of the filter (16 litres in total). This is a sufficient volume to supply a family of four with two litres of drinking water each for a duration of two days. The receptacle can therefore decrease in size from the Filtron filter's receptacle (holding up to 40 litres).
- The filter should be easy to disassemble and to replace parts, easily maintainable, with filter disassembly undertaken without specialist tools.
- The filter receptacle should ideally be moulded by using a transparent or translucent material, allowing for easy observation of the filtered water level, as well as any build up of particles or insects within the filter element.
- The instruction leaflet should be included in the filter unit, thereby providing the user the opportunity to refer back to the leaflet to remind him/herself, or to inform another family member on correct filter usage and cleaning. This should be mainly in a pictogram format to overcome illiteracy levels prevalent in rural communities.

4.2.1.1 Considerations for manufacturing and distribution

- The filter components should be stackable and take up as little shop space as possible. Parts could either stack into piles of the same item, or all components of the filter assembly could possibly fit inside the receptacle.
- Suitable manufacturing methods will need to be explored to identify what method of production would yield components with the lowest production cost, while maintaining the required filter properties; i.e. a good cost-to-benefit ratio.
- Suitable materials and the applications of such materials should be considered for cost-effective production of the filter components. Characteristics of materials should suit the environment where the filter will be used i.e. food grade, hard wearing/long lasting, versatile, easy to clean.
- *"Plastic receptacles should be encouraged over ceramic"* (Alethia Environmental, report 2:1).

- If parts of the filter break, they need to be available and easy to replace, i.e. designed and manufactured for disassembly, where users can replace parts with minimum tools.
- The exploration of ceramic filter manufacturing should possibly utilise local community potters and materials.
- The complete, assembled filter should consist of as few components as possible. This will keep the manufacturing costs to a minimum.
- If the design of the improved water filter proves to be suitable to consumers in South African rural areas and viable to manufacture, compared to importing the existing Filtron filter, local manufacturing could be pursued. If this takes place, Potters For Peace could assist in establishing a local factory or community-based project (PFP: 2006b). Filter elements can be manufactured locally, thereby providing local employment, eliminating import costs and shipping taxes and therefore creating a more sustainable solution compared to importing filter elements.
- *"The colour of an item influences the perception of it and this is used extensively in marketing. It is usually the first thing that attracts a consumer to a product... Foodstuffs claiming to be pure and unadulterated often use blue and white packaging to communicate purity"* (Wilson and Challis, 2004:176). The filter and filter components should therefore be in colours that users would associate with characteristics such as hygiene, purity and health. Light colours could be considered to allow users to observe whether components are dirty and need cleaning. The receptacle should be moulded from a translucent plastic allowing for easy monitoring of level of filtered water.

4.2.1.2 Existing strong-points of Filtron filter

- The form of the existing Filtron filter is stable, it is sufficiently stable.
- The individual disassembled receptacles are stackable (on top of each other).
- The individual disassembled retaining rings are stackable (on top of each other).
- The individual disassembled covering lids are stackable (on top of each other).
- Polypropylene as the material choice for the receptacle, filter retaining ring and lid makes the product strong and easy to clean.
- The translucent receptacle allows for easy observation of the filtered water level.
- The covering lid is lightweight and is easy to lift.
- The assembly of the filter is relatively simple: parts fit well, and no fasteners are necessary (except for the spigot).

- The spigot of the Filtron filter is good. It is a standard component that fits through a hole in the receptacle wall. It supplies water at a suitable rate. The re-designing of this component is unnecessary, as it functions well. Alternative and innovative methods to retrieve water should be investigated to explore if a lower cost options can be developed with the same or better benefits.
- The volume of the receptacle as well as the filtration rate of the filter is adequate. Therefore, the current filter is of a suitable size and does not need to be altered.

4.2.2 Medium Priority: Secondary design requirements: Should be included in the improved water filter but are not as important as the main design requirements.

- The improved filter's covering lid should be suited to lifting easily by an incorporated handle, as well as by its edges. Hand grips should conform to use and should be comfortable and ergonomic (Tilley, 1993:74).
- The filter receptacle could incorporate a visual indicator signalling a suitable height of filtered water in the receptacle to maintain water in the receptacle and increase filtration rate by motivating the user to keep water in the filter.
- The receptacle volume should approximately be two filter fillings, i.e. 16 litres.
- The spigot of the filter should ideally be opened temporarily as well as provide a constant water flow, as in the Filtron filter.
- The filter components should contain as few dirt traps as possible while retaining its rigidity and ultimately its ability to assemble to a tight tolerance.
- The filter should comprise as few components as possible. The retaining ring could be eliminated, cutting down on the number of manufactured components and reducing production wastage, thereby decreasing unit cost. This was a value engineering exercise.
- The form and construction of the improved filter should allow for post-use functionality (filter element - flower pot/storage pot; receptacle - storage vessel; stand - useable surface).

4.2.3 Low Priority: Other design requirements: Not as important as Medium and High priority, but would prove beneficial to some users or would improve the usability or effectiveness of the filter.

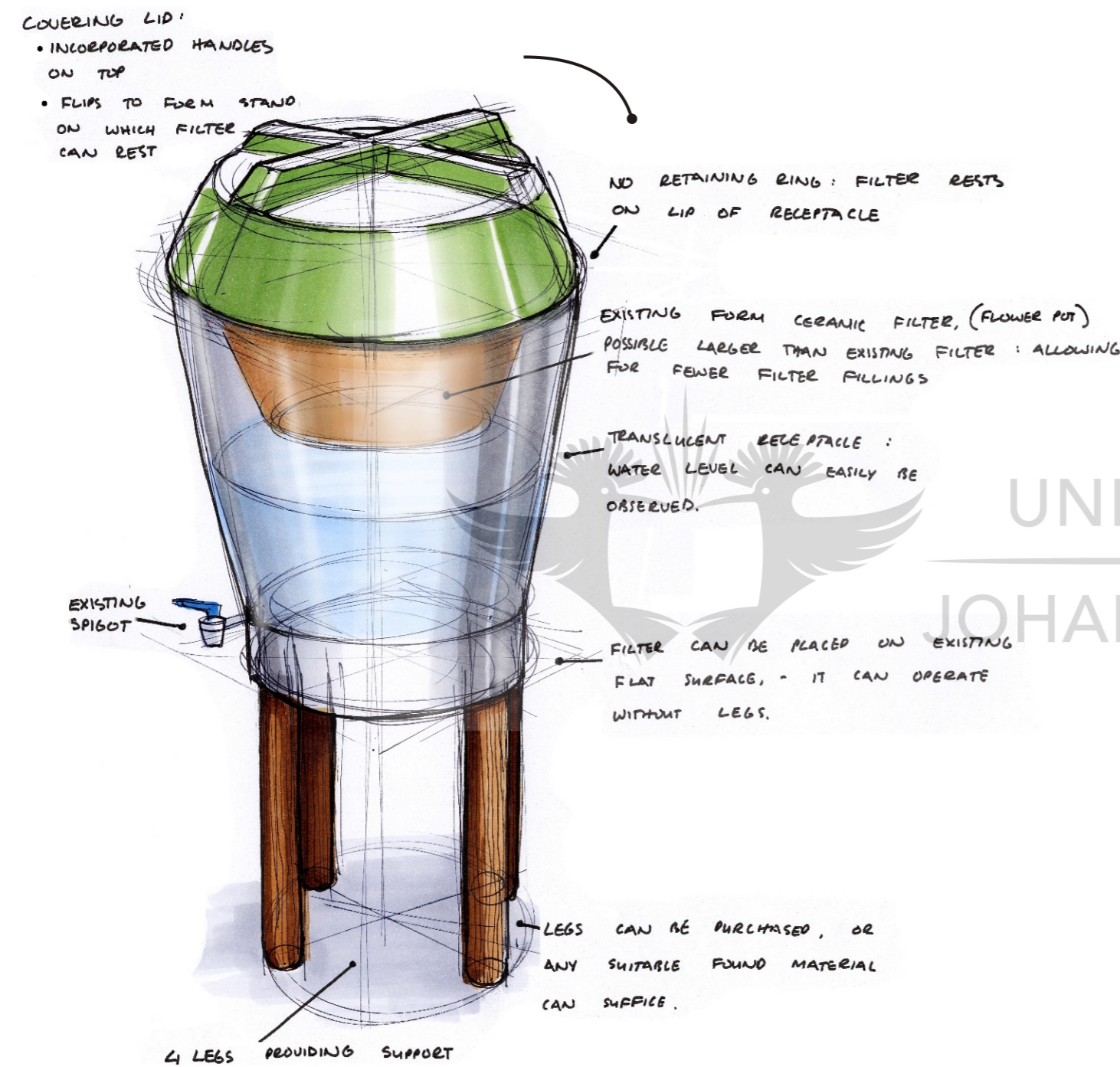
- An angled face of the bottom surface of the receptacle would allow for maximum filtered water usage.

- Moving the spigot to the lowest possible point in the receptacle will allow for maximum filtered water usage.
- A pictogram could be included on the receptacle, close to the spigot, showing the various spigot positions: locked open and temporarily open.
- The improved filter could possibly incorporate a stand for the filter element to rest on, while the receptacle and filter element are cleaned by the user.
- The improved filter could possibly incorporate a holding mechanism to hold a container while the spigot provides water. The user does not need to hold it up to the spigot to fill. This mechanism could possibly be incorporated into the receptacle stand.

4.2.4 Synopsis

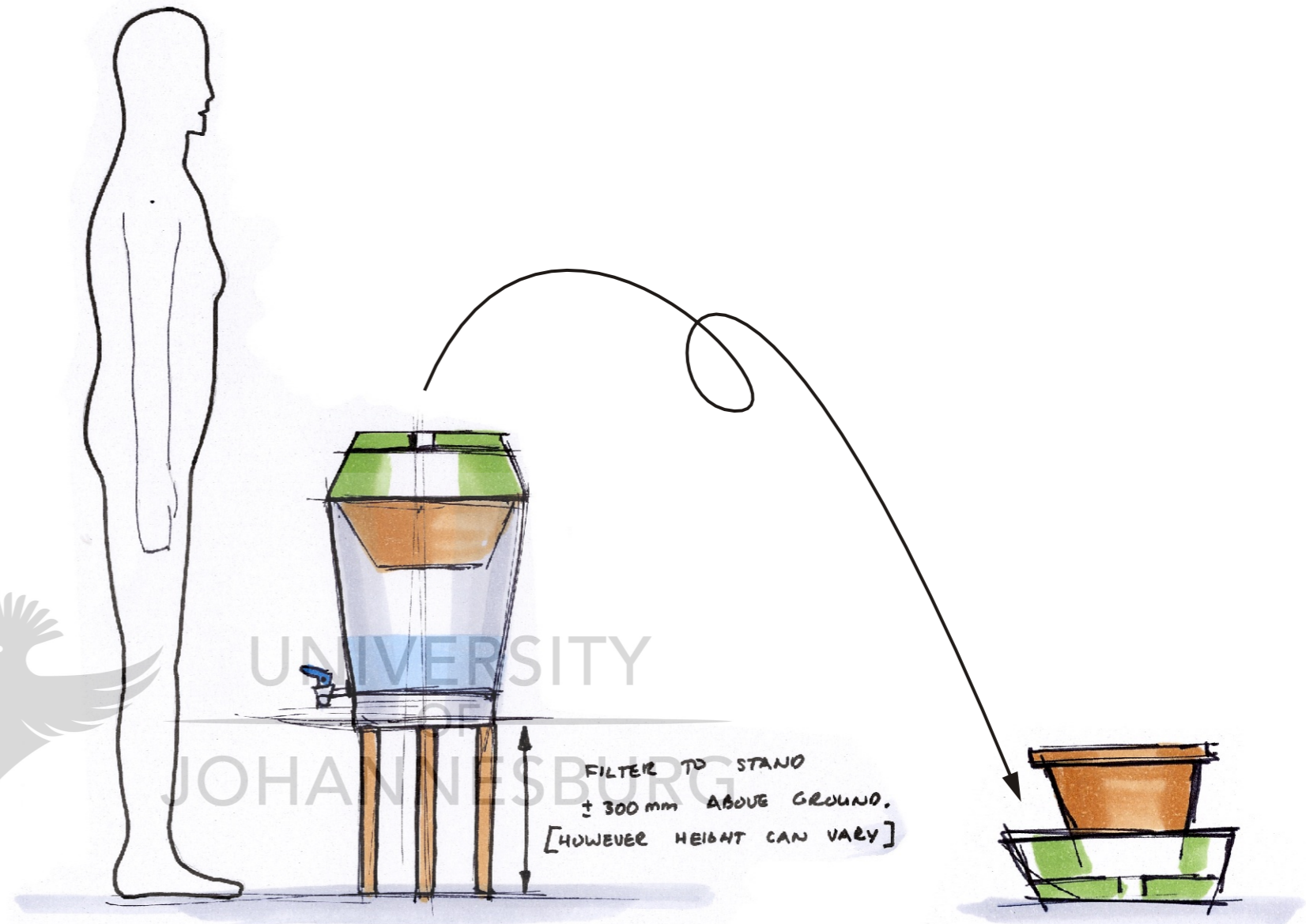
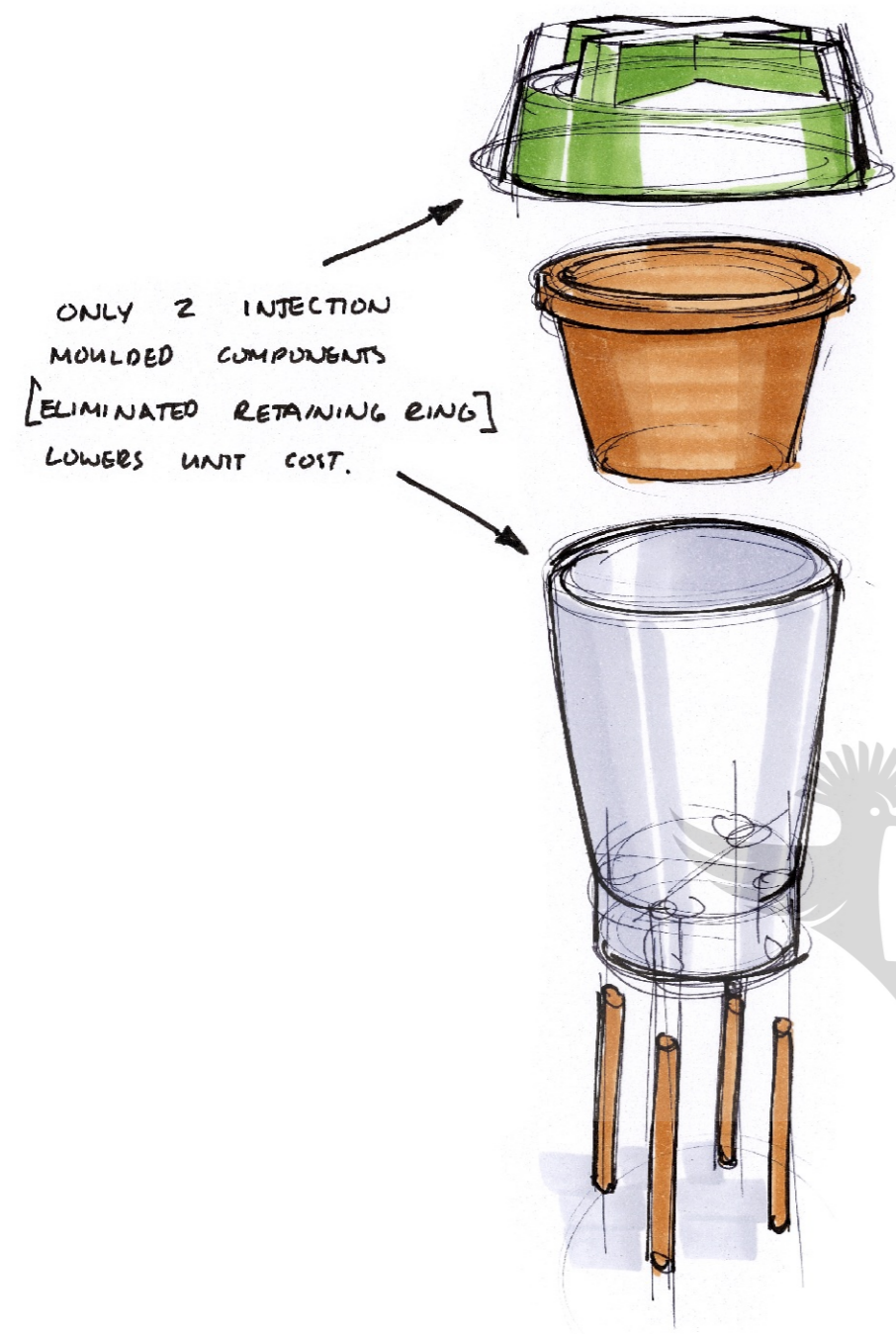
Solutions to the design requirements were explored by means of concept sketching. All the drawings are bound into one document for the purpose of this project, but the most important concepts were included and discussed in this dissertation. Of the varied solutions to the observed problems, many proved to be unviable to incorporate in a final design for various reasons. Some of these include increased manufacturing costs, an inability to stack, or complexity of filter assembly. However, the solutions that were viable to consider have been incorporated into three filter concepts. Each of these concepts will be discussed and their features explained. By referring to the list of design requirements, it will be possible to observe what design aspects satisfy the design requirements and are viable to include in the final design. Aspects from the three chosen concepts were combined into one final design that was developed into a final, resolved solution satisfying as many of the design requirements as possible without adding unjustified product cost. In all the concept directions it was decided to continue to use the Filtron/Potpaz ceramic filter, due to the fact that it has been extensively tested and proved to be an effective filtration mechanism. The manufacturing requirements have already been researched and are available for use in the improved filter (annexure 21). The other element of the Filtron filter that has been included in all the concepts is the spigot. Its cost, and compatibility are suitable to be included, without the need for the added cost of new tooling for manufacturing a new design.

4.3.1 Conceptualisation: Concept one

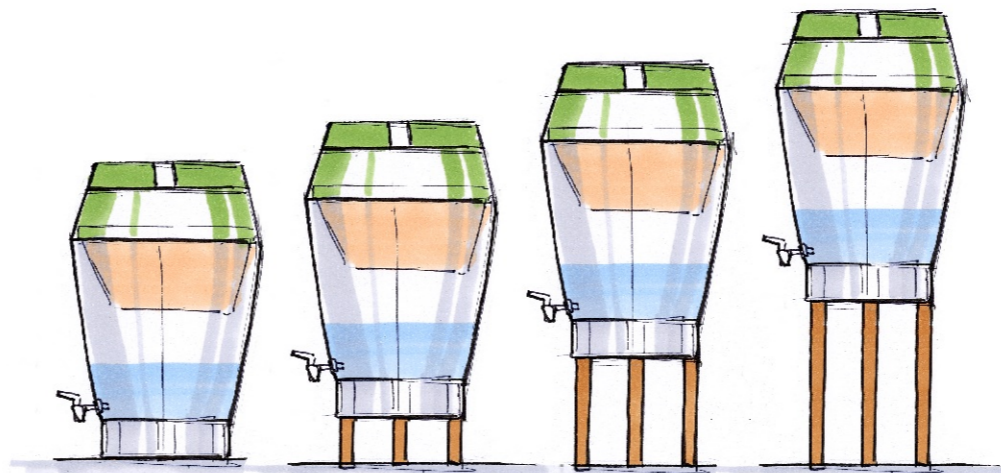


Synopsis of Concept one

This filter concept consists of an injection moulded translucent receptacle into which the ceramic filter is inserted. The translucent plastic allows for easy observing of the filtered water level within the receptacle. The ceramic filter rests on the rim of the receptacle and no filter retaining ring is required (decreasing total filter cost). The spigot is inserted through a hole near the bottom of the receptacle. On the underside of the receptacle there are four locating points where legs fit into the bottom of the receptacle allowing for the receptacle to be placed above the ground. Because these legs are a standard component (replacement broom handle, with a diameter of 24mm), users need not purchase specially manufactured legs for the filter. They have the option of utilising whatever suitable materials they have at hand. This could be wooden rod retrieved from a broken broom handle, or even sticks of a suitable diameter. Alternatively, users could stand the filter on an existing flat surface. If the users are comfortable with floor placement, the filter can stand directly on the floor, as the spigot is high enough to allow for a small container to fit beneath it. The loose fitting covering lid has incorporated handles, allowing for easy holding and lifting. A further design feature of the lid allows for it to be inverted and used as a clean placement surface where it can be placed during cleaning.



HEIGHT OF FILTER CAN BE
ALTERED BY CHANGING
LEG LENGTHS.



Concept 1

Positive Points

There are only two moulded components (no filter retaining ring). The ceramic filter rests on the receptacle, therefore lower manufacturing costs for a number of parts.

Both of the filter components (receptacle and lid) are suited to mass manufacturing, allowing for low unit costs when high volumes are manufactured.

The existing Potpaz filter element is to be used, therefore all manufacturers of the Potpaz filter would be able to utilise the plastic components together with the currently manufactured filter.

The receptacle has incorporated locating points for separate legs, eliminating the need for an existing surface onto which the filter is to be placed. Users can adjust the height of the filter to their needs or preferences.

Support legs can be purchased. Alternatively, users can utilise any suitable found items that will suffice (broom handle, found stick).

As an alternative to constructing a stand from found items, a base is included in the receptacle, allowing the filter to stand directly on the floor if users so wish.

The lid can be inverted and used as clean surface on which the filter element can rest during routine cleaning.

The receptacle is translucent, allowing for monitoring the height of filtered water.

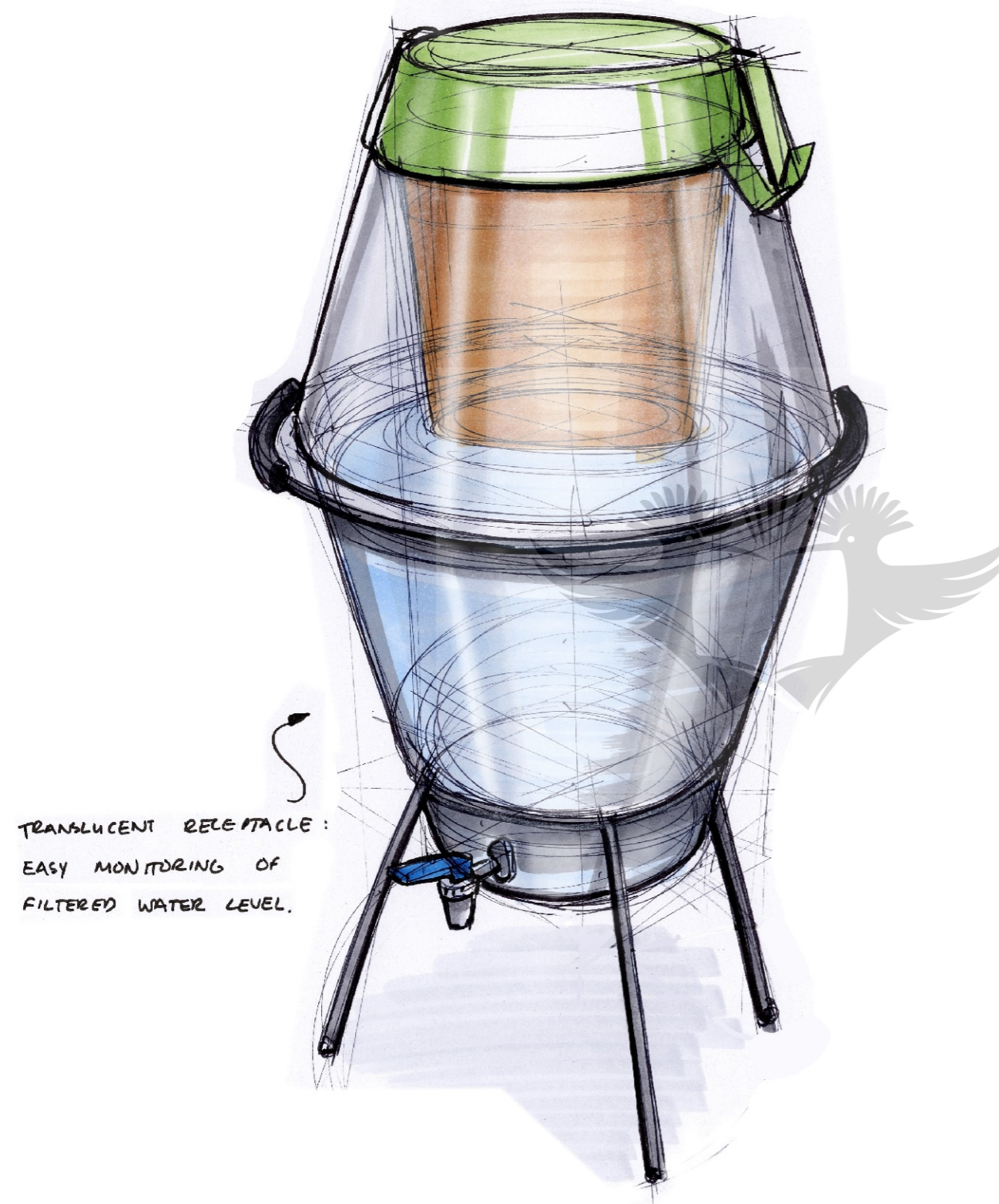
Negative Points

If users cut their own legs from sticks, they have no way of telling what an appropriate height would be. This ideal height could possibly be indicated on the filter.

The incorporated base would affect the stacking of receptacles. The higher the incorporated base, the less effectively the components will stack.

If the user has the filter raised relatively high above the floor (500mm), it may prove difficult for him/her to fill the filter if they do so using a large container.

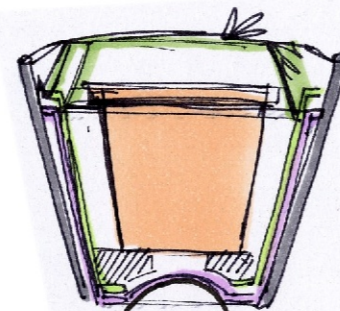
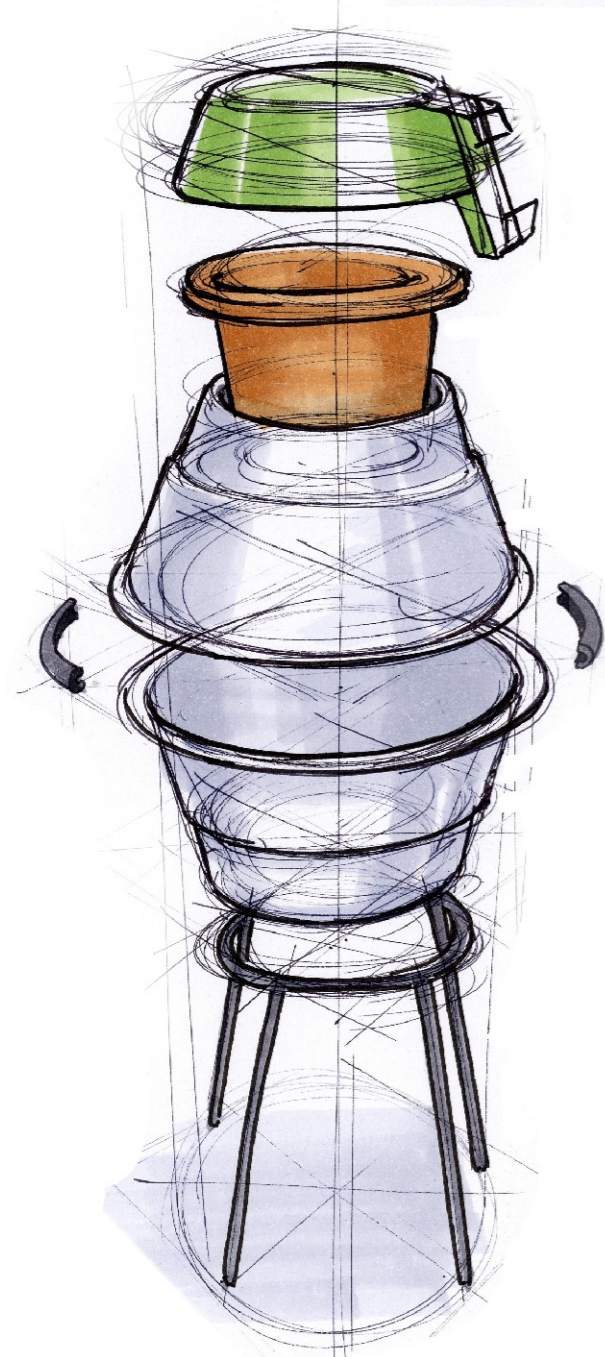
4.3.2 Conceptualisation: Concept two



Synopsis of Concept two

This filter concept consists of two components manufactured from identical mouldings, being the receptacle and the retaining ring. These mouldings are injection moulded, using a translucent plastic allowing for the observation of internal filtered water level. The two mouldings locate onto each other and are held in place with several clips, that also create ergonomic lifting points. The ceramic filter fits into the retaining ring and does not occupy the internal volume of the lower receptacle. This concept allows the entire internal volume of the receptacle to be filled with filtered water. The Filtron filter only allows for approximately half of the volume of the receptacle to be utilised for filtered water storage. This allows for the same filtered water storage volume as the Filtron filter, with a receptacle that is roughly half the height. It decreases the tooling costs of the injection moulding process, and allows for effective stacking of components since the mouldings are identical. The underside of the receptacle has a slight indentation, matching the curvature of the top of a person's head, allowing for ergonomic carrying of the receptacle. This is typically how the product will be carried from purchase at a spaza shop to the consumer's home. A spigot is inserted through a hole near the bottom of the receptacle. The receptacle is supported by a metal frame made from mild steel round bar, bent and welded. This will provide sufficient support for the filter and can be manufactured at a community level, requiring basic tools, as well as on a mass manufacturing level. The covering lid of the filter has two handles on the sides, allowing for easy lifting. It can be used to fill the filter when holding these two handles. The internal volume of the covering lid equals the internal volume of the ceramic filter, thus making filling the ceramic filter easy, as the user only needs to scoop one lid full of water into the filter at a time, or pour from a heavy 25 litre drum into the lid on the floor. Once the lid is emptied of unfiltered water into the ceramic element, it can immediately be replaced to cover the filter. If the user does not use the lid for filling the filter, an incorporated hood on the covering lid allows for the lid to hook onto the edge of the receptacle. This prevents the lid from having to be placed on the floor or any nearby surface. All filter components nest into each other, allowing for users to easily transport the filter unit back to their households by carrying it on the top of their head.

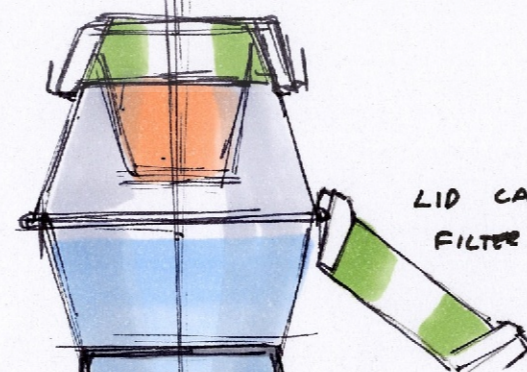
INCORPORATED LIFTING HANDLES



STAND, FILTER, RECEPTACLE,
SUPPORT RING, LID, & SPIGOT
ALL TIED TOGETHER, & SIT
COMFORTABLY ON ONE'S HEAD
[TRANSPORT FROM SHOP TO HOUSE]



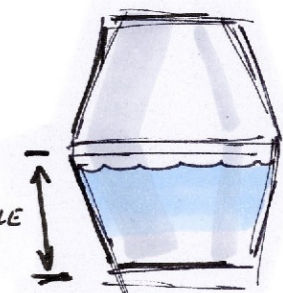
UNIT CLIPS TOGETHER,
& CAN EASILY BE
LIFTED.



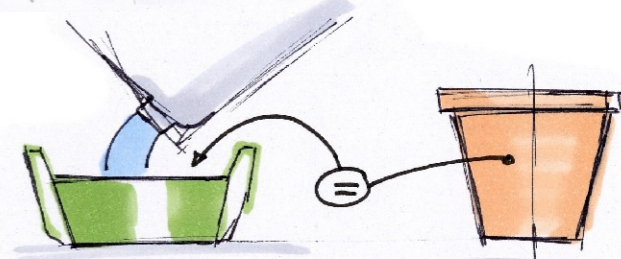
LID CAN HANG ON
FILTER UNIT

↑
FILTER TO STAND
NO LOWER THAN
200 MM.
↓

ENTIRE VOLUME OF RECEPTACLE
CAN BE USED:



COVERING LID CAN BE USED
FOR FILLING FILTER





Concept 2

Positive Points

The receptacle and filter retaining ring are made from two of the same mouldings, with a hole being cut in the top component. This forms the retaining ring to allow for the ceramic filter to be inserted. This allows for lower tooling costs compared to separate moulds being made for each component.

The receptacle, retaining ring, and covering lid are suited to mass manufacturing, allowing for very low unit costs when high volumes are manufactured.

The entire volume of receptacle can be filled with filtered water.

The bottom floor of the receptacle includes a recess that would allow the receptacle to rest comfortably on the user's head for transporting the unit from shop to household.

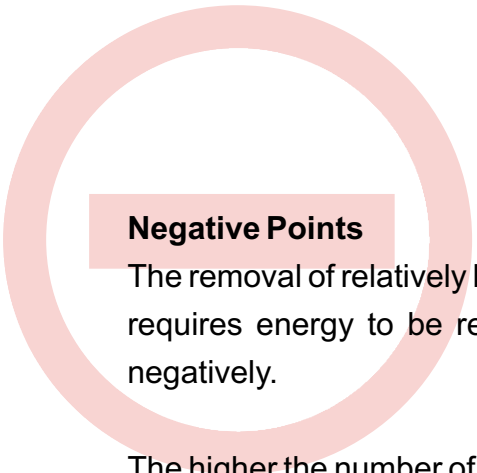
Two mouldings are clamped together, using clips that act as ergonomic lifting points.

The filter fits into the supplied metal support stand, eliminating the need for an existing surface.

The covering lid includes incorporated handles and can be used for filling the filter, as it holds sufficient water for one filter filling.

The covering lid can hook onto the edge of the receptacle, as it contains an incorporated hanging hook.

All components stack effectively into each other, making the transportation of the filter unit back to the user's household very simple. This is enhanced due to the ergonomic recession on the underside of the receptacle.



Negative Points

The removal of relatively large parts of plastic produces much wastage which requires energy to be recycled, affecting the manufacturing cost of units negatively.

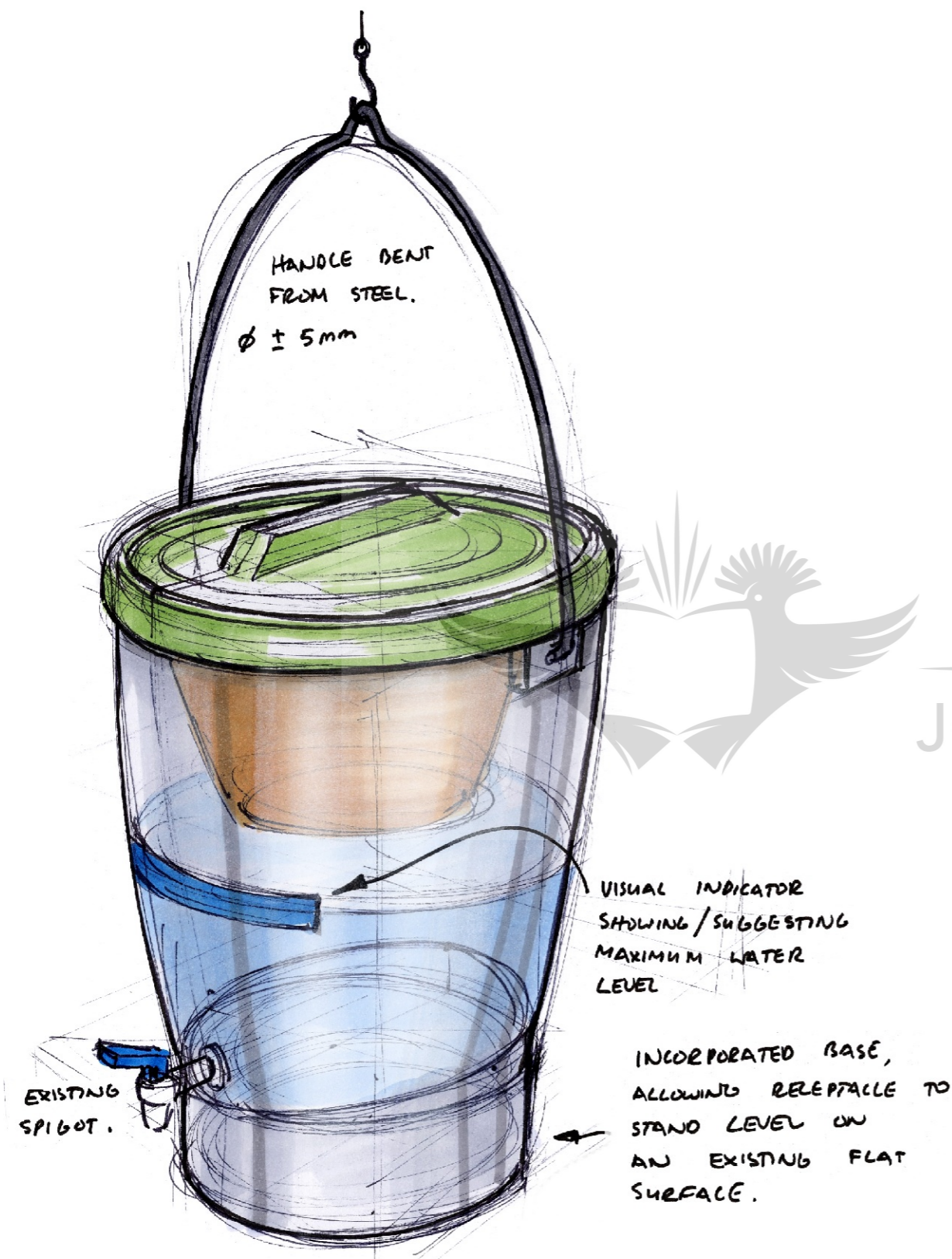
The higher the number of manufactured components, the higher the unit cost per filter. The receptacle, retaining ring and clip-on handles in this concept consists of four components, possibly producing a relatively high-costing filter.

The cost of manufacturing of the wire stand could prove expensive as several processes are included, those of: cutting, bending and welding. This, together with the material cost, would produce a high-costing product.

There is no adjustment of height for the filter once the stand is in place. Users are restricted to the existing height of the metal stand.

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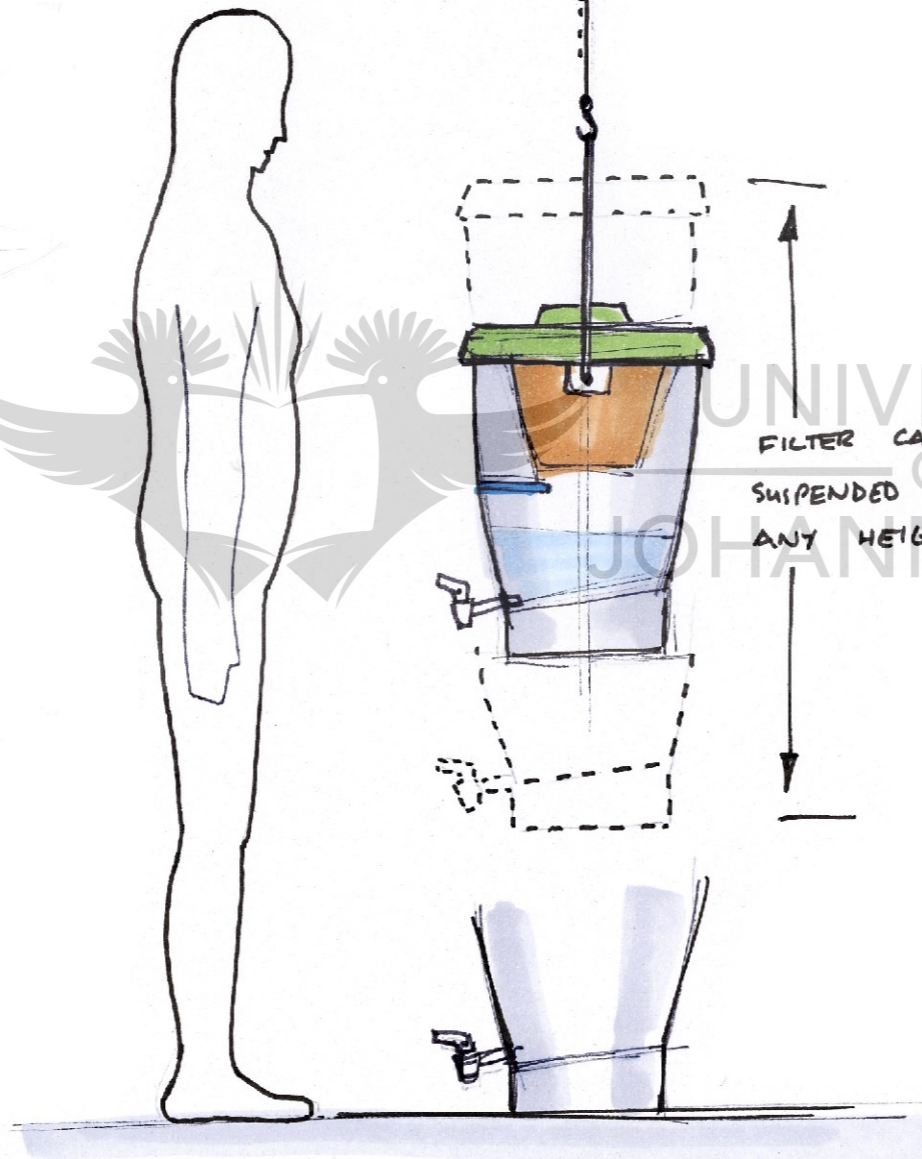
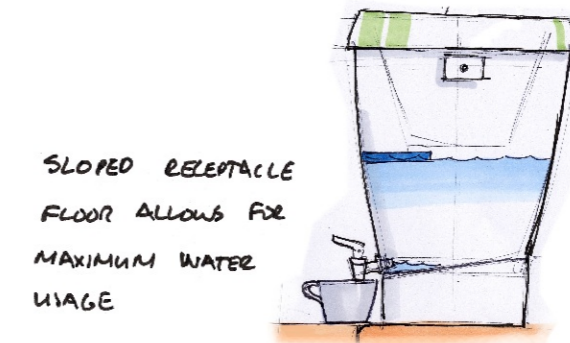
4.3.3 Conceptualisation: Concept three



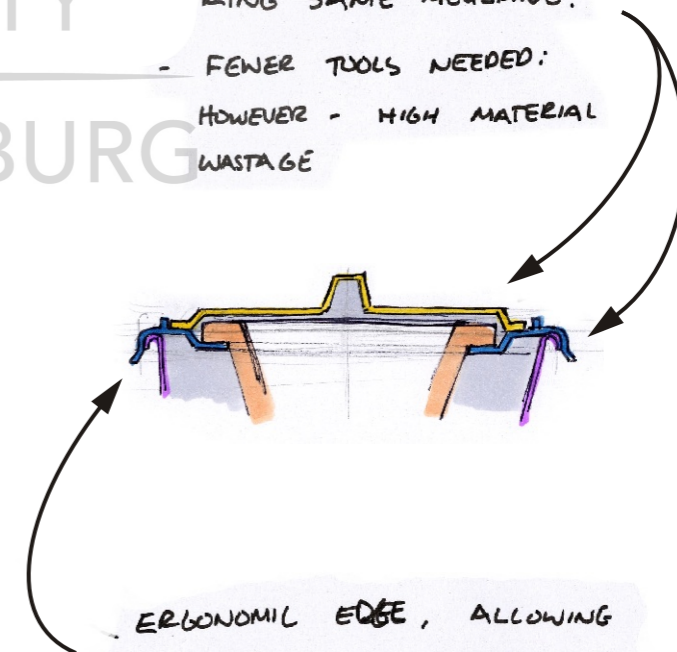
Synopsis of Concept three

This filter concept consists of a translucent injection moulded plastic receptacle in which the ceramic filter is suspended and supported by a retaining ring. This concept has a similar layout to the existing Filtron filter, but the design differs, as the filter unit is suspended (hangs) from above and does not necessarily require support from a flat surface on the ground. The handle by which the unit is suspended is bent from a suitable thin gauge rod and can swivel out of the way or be removed if not needed. The filter unit can still rest on a flat surface, as the underside of the receptacle contains an incorporated base. The user has the option of suspending the filter or resting it on an existing surface or on the floor. There is sufficient room between the spigot and floor to fit a small retrieving receptacle (teacup for instance). The internal base of the receptacle is not level as in the Filtron filter. It slopes slightly, with the spigot placed at the lowest point. This allows for maximum water consumption, as the water runs down to the spigot without the user having to resort to tilting the filter to retrieve most of the filtered water. The covering lid and filter retaining ring are made from the same moulding, decreasing tooling costs for injection moulding. A hole is cut from the inside of the retaining ring, allowing for the filter to be inserted. The rim of plastic from the covering lid is also cut away, allowing for the lid to locate on the inside of the retaining ring. The unfortunate disadvantage of this is also found in the Filtron filter, and this is the wastage of material in manufacturing that will inevitably add to cost for the environmental impact of the product. The covering lid contains an incorporated handle and can be removed while the filter is suspended, as the hanging handle does not interfere with this operation. Furthermore, the hanging handle can be used for transporting the filter unit from the spaza shops, back to the rural households. There is a visual indicator applied to the side wall of the receptacle, indicating maximum water level. The hanging rope could be supplied with the filter unit, offering households the option to utilise the hanging option if they wish.

- FILTER CAN BE SUSPENDED FROM CEILING / BRACKET / WALL ... ETC.
- FILTER HAS FLAT BASE, RAISING SPIGOT ABOVE SURFACE, ∴ FILTER CAN ALSO STAND ON FLAT SURFACE.



- LID & RETAINING RING SAME MOULDING.
- FEWER TOOLS NEEDED: HOWEVER - HIGH MATERIAL WASTAGE



ERGONOMICAL EDGE, ALLOWING FOR RETAINING RING TO EASILY BE CLIPPED OFF OF RECEPTACLE.



Concept three

Positive Points

The filter retaining ring and covering lid are made from the same moulding, allowing for lower tooling costs compared to separate moulds being made for each component.

The covering lid can be lifted from the filter while the filter remains suspended. The handle does not interfere with the removal of the lid in the suspended position.

The filter can be suspended above the floor by a metal hanging handle purchased with the filter. Users have full adjustability with regard to the height of the filter above the floor through the adjustment of the length of the hanging rope.

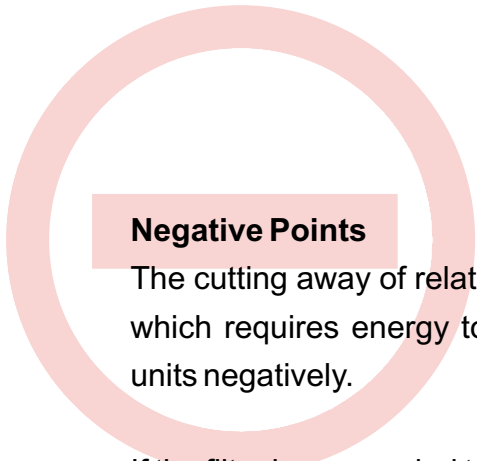
The metal handle could be an extra item bought with the filter if users wish to hang the filter. It need not be included in the filter assembly.

The receptacle is moulded from translucent plastic and incorporates a visual indicator suggesting the maximum height of filtered water.

The receptacle includes a base, allowing for the filter to rest on an existing surface.

The base is high enough to allow for a small container to fit between the spigot and placement surface.

The bottom floor of receptacle slants, allowing for maximum filtered water usage.



Negative Points

The cutting away of relatively large parts of plastic produces much wastage which requires energy to be recycled, affecting the manufacturing cost of units negatively.

If the filter is suspended too high above the floor filling the filter element could prove to be difficult.

Many households do not have roofing strong enough to support the weight of the filter unit, therefore the hanging option should not be the only method of filter support. This unknown factor could have a serious impact on the ergonomic height setting of this product.

The incorporated base would affect the stacking of receptacles. The higher the incorporated base, the less effectively the components will stack within piles of the same item.

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4.3.4 Elements to include in the final design

Aspects have been included from all concepts, to be considered for inclusion in the final design.

Receptacle:

Translucent: Allowing for observing the level of filtered water and water sediment and insects within the lower receptacle.

Stackable: Can be easily transported, and stocked in spaza shops.

Stable: Must be as stable or more stable than the Potpaz filter.

No Filter Retaining Ring:

Minimising the number of manufactured parts, lowering unit costs. The filter element rests on the rim of receptacle.

Existing Potpaz Filter Element:

The current filter is effective. Redesigning this component is unnecessary.

Receptacle, lid and stand:

There is the possibility of exporting the components to filter manufacturers in other countries who already are manufacturing the Potpaz ceramic filter element.

Spigot:

The existing Spigot is a standard component which operates effectively. It is assembled into receptacle with no tools being required.

Hanging Handle:

Provision should be made for a hanging handle. This can be bought separately and clips into place, allowing for the filter to be suspended from above.

The handle should not interfere with the lid when the unit is suspended.

Covering Lid:

Can be used as a stand on which the filter can rest during routine maintenance.

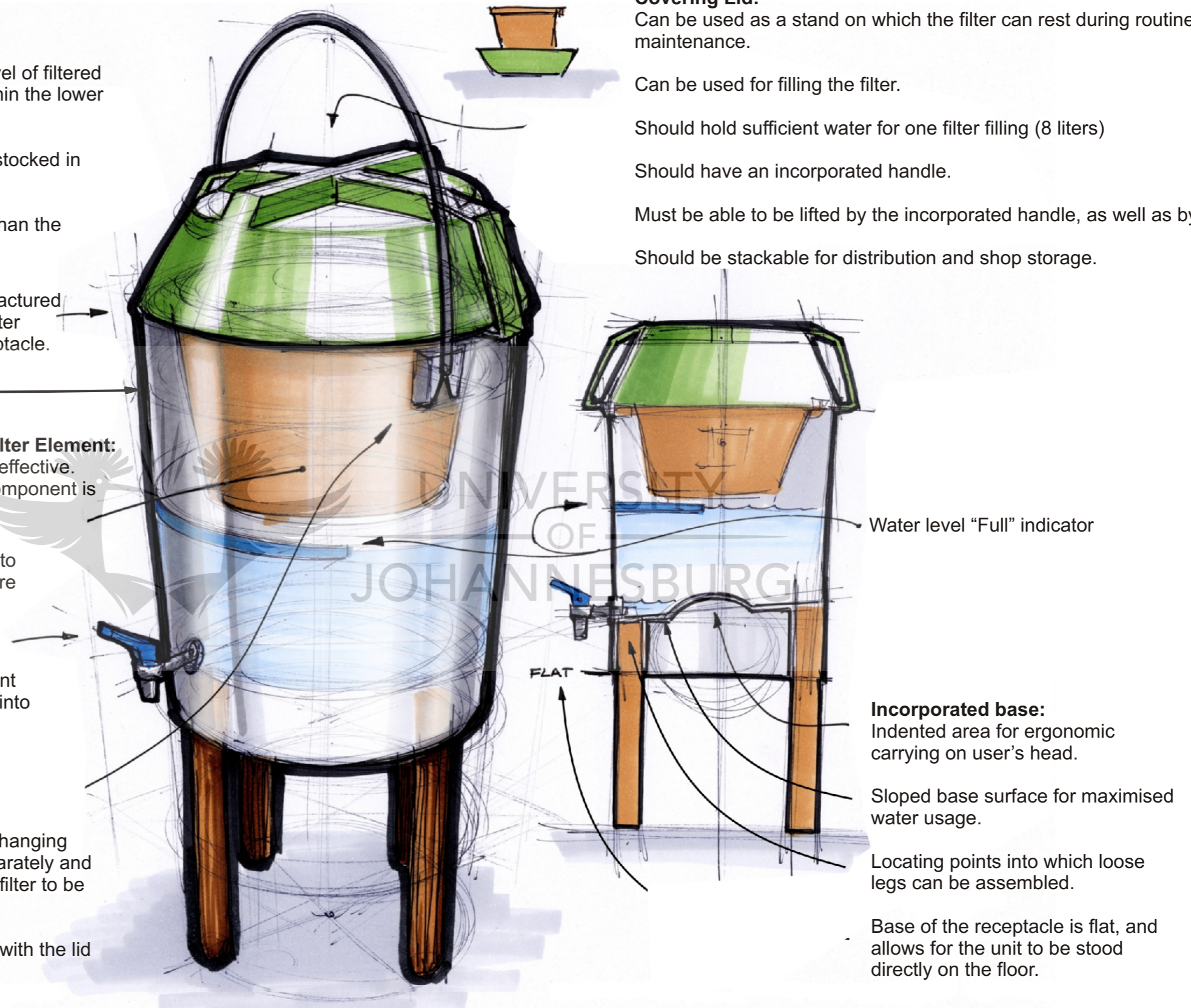
Can be used for filling the filter.

Should hold sufficient water for one filter filling (8 liters)

Should have an incorporated handle.

Must be able to be lifted by the incorporated handle, as well as by its rim.

Should be stackable for distribution and shop storage.



Water level "Full" indicator

FLAT

Incorporated base:

Indented area for ergonomic carrying on user's head.

Sloped base surface for maximised water usage.

Locating points into which loose legs can be assembled.

Base of the receptacle is flat, and allows for the unit to be stood directly on the floor.

4.4 Design development

As each of the three concepts satisfies different design requirements, the final design should include all the beneficial aspects of these initial concepts. This way, the final water filter design will be able to fulfil as many of the design requirements as possible. The development of the final design was sketched on paper as well as on the computer, utilising various software packages. Graphic design software allowed for fast and effective manipulation of two-dimensional profiles of the filter components. A three-dimensional CAD¹⁸ modelling package allowed for accurate modelling of components and the calculation of their internal volumes. With the use of the CAD software, parts could be assembled within the software package, allowing for simulation of real assembly once modelled on the computer. Once the design was developed to a satisfactory level, it became necessary to make development models to assess the scale and stability of the design. This was necessary as the diameter of the receptacle in the improved design was reduced from that of the Filtron filter, in order to eliminate the need for the filter retaining ring in the Filtron filter. This smaller diameter would result in legs that had a smaller area of stability than the Filtron filter. A development model was required to test if this smaller footprint would affect stability negatively.

4.4.1 Developmental prototype: stability test model

From the CAD model of the filter, model-makers' drawings were compiled and the test model created as follows.

- Standard wooden dowels and an Addis¹⁹ plastic bucket were purchased to be used for the support legs and receptacle respectively. The Addis plastic bucket was chosen because it had the same diameter opening as the final designed receptacle.
- A wooden support platform was made by fastening wooden dowel sections to a suitably sized disc of 16 mm Supawood (fig. 4.1). The attached legs were cut to the same length as the legs of the CAD model (fig. 4.2).



Fig. 4.1 Dowel and 16 mm Supawood ready to assemble



Fig. 4.2 Wooden support platform constructed

- A spacer was created from 3 mm Masonite²⁰ sheeting. The size of this raised the plastic bucket to the correct height above the wooden support platform to replicate the final concept design. It was fastened securely to the wooden support, using several large cable ties (fig. 4.3).

¹⁸ Computer Aided Design

¹⁹ Addis is South African brand offering a diverse product range encompassing household cleaning products, kitchen and home plasticware, gardenware and hardware.

²⁰ Masonite is brand name for a South African manufactured fiberboard.



Fig. 4.3 Masonite spacer

- Holes were then drilled in the floor of the receptacle, allowing for the fastening of the receptacle to the constructed wooden base and spacer, using cable ties (fig. 4.4).

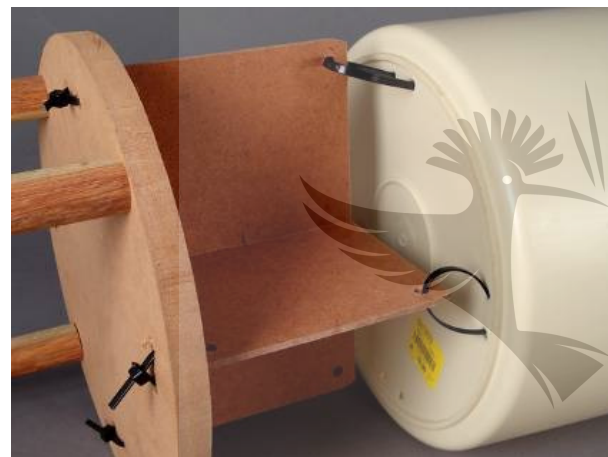


Fig. 4.4 Support attached to the receptacle

- The complete stability model was skinned with a layer of brown paper to create a similar aesthetic appearance as the receptacle in the CAD model (fig. 4.5)



Fig. 4.5 Developed CAD model and stability prototype made from CAD model

- A simplified model of the covering lid was constructed from standard single fluted cardboard and gum tape, in order to replicate the visual height the lid would add to the receptacle (fig. 4.6).



Fig. 4.6 Construction of simplified covering lid

4.4.2 Conclusions from the stability test model

By means of interfacing with and testing the model it became evident that it was very unstable. The instability was due to the size of the footprint of the filter, being 190 mm by 190 mm square. This was much smaller than the existing Filtron filter that has a stability footprint of Ø280 mm. This stability problem needed to be solved by increasing the footprint of the design. The support legs would have to be moved further from the centre (fig. 4.7).

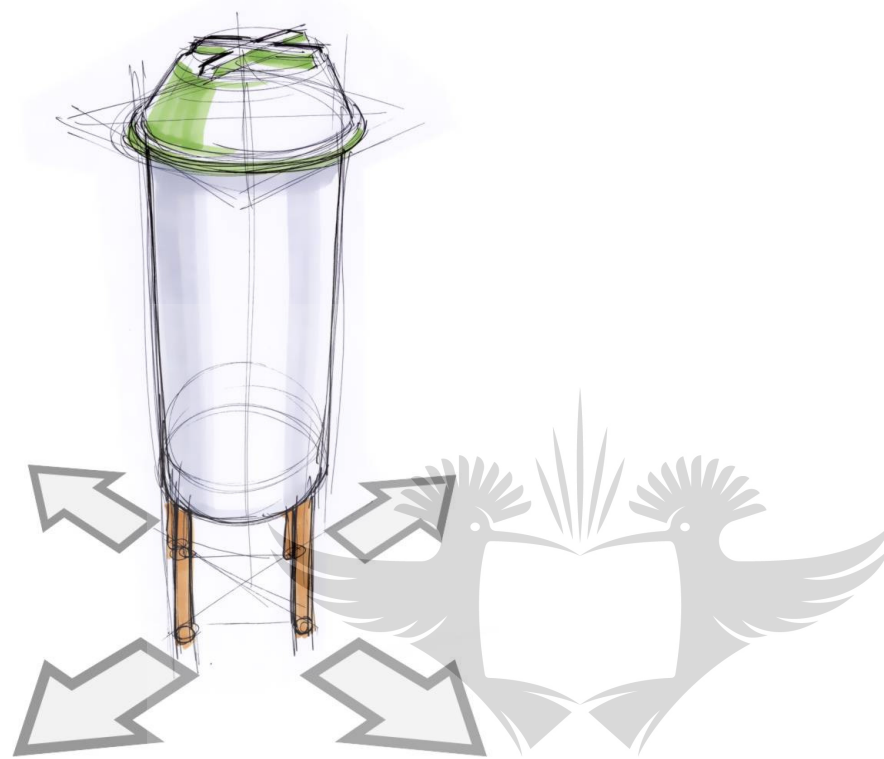


Fig. 4.7 Spreading the legs increases the stability footprint

One option to resolve the problem was to locate the legs around the upper rim of the receptacle (fig. 4.8). The legs would need to be longer to reach this height, in turn increasing material for the legs and the costs. In order to maintain stability over the length of the legs they would also need to be attached at the base of the receptacle. The fastening at the base would require more material in the form of either a plastic bracket, metal retaining spring, or metal bracket (fig. 4.8). This addition of components, material and complicated assembly would nullify the cost-saving of the receptacle's reduction in size. Furthermore, providing a solution depending on relatively complex assembly and a large number of parts, defeats the primary aim of increasing usability by creating areas of possible confusion and frustration for users.

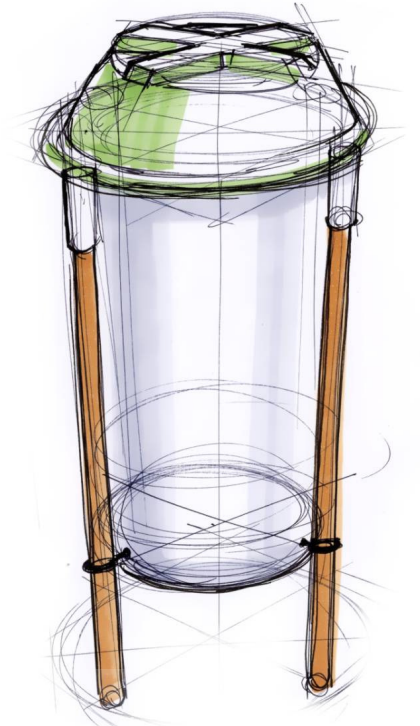


Fig. 4.8 Legs located around the receptacle rim

The second option to resolve stability was to create a separate stand with wider legs. This stand could locate around the base of the receptacle and then have legs that flared out to increase stability, using minimal material to keep the receptacle at the correct height. This stand could be made as one component. The ready-to-use stand was designed to be one component into/onto which the receptacle rests. It was to be mass-manufacturable, utilising as few manufacturing processes as possible to allow for the lowest unit costs. The receptacle needed to easily assemble into the stand with as few areas of complication as possible. The method of manufacturing and choice of material best suited to this would be injection moulding, using Polypropylene plastic. This is the same type of plastic from which the covering lid and receptacle were to be manufactured and the same material used in the Filtron filter. It would allow for a robust stand with the same material properties of the other main components comprising the filter assembly.

4.5 Final design

The final design comprises three main plastic components, a bent wire hanging handle, the existing Filtron/Potpaz ceramic filter element, and the existing Filtron plastic spigot (fig. 4.9). The three main plastic components are all injection moulded using a food grade Polypropylene plastic and are as follows: receptacle, stand, and lid.



Fig. 4.9 Improved filter

A summary describing the features of the overall design as well as each component is provided below:

Improved filter: summary of features:

- The filter unit can stand in all the main rooms of the households, not only in the kitchen.
- The filter can stand directly on an existing flat surface in the household, in the stand (provided with the filter), as well as suspended (hung) from above. This gives a wide variety of placement options to the user.
- While utilising the supplied stand, the filter rests at a suitable height, allowing the user to retrieve water without having to bend over uncomfortably, as well as low enough to the

floor to allow the user to comfortably fill the filter element by using various water storage containers.

- If utilising the stand, the spigot is at 250 mm above the floor, fitting into the height range in the design requirements (between 200 mm and 800 mm above floor level).
- Because of the footprint of the stand, the improved filter is more stable than the Filtron filter when in the supplied stand.
- All areas where lifting and holding is intended, have been considered in terms of ergonomics and comfort.
- The improved filter is suited to dispense water to any type of container, from a small teacup or glass, to small plastic buckets and jugs.
- The filter is easy to disassemble and to replace parts.
- The filter is easily maintained, with filter disassembly requiring no specialist tools.
- The filter units are stackable for easy transport and storage.
- Main components are manufactured from food-grade, hard wearing/ long lasting, and easy to clean Polypropylene plastic, suited to mass production.
- The complete assembled filter consists of as few components as possible. This keeps the manufacturing costs to a minimum.
- There are no water traps. If filter is overfilled, the water will run off the receptacle, not mixing with the filtered water.
- The filter components contain few dirt traps while at the same time retaining rigidity created by means of its forms, allowing for tight assembly tolerances.
- The spigot of the filter has two open positions: temporary flow and constant flow.
- The form and construction of the improved filter allows for post-use functionality e.g. The filter element could be used as a flower pot/ storage pot. The receptacle could be used as a storage vessel. The stand could be adapted into a stool/low table. The covering lid could be used as a storage bowl or pouring vessel).
- The colour of the covering lid and stand are grass green. This is a bright colour, making it easy to observe if the components are dirty and need cleaning. The receptacle, however, is translucent, allowing for easy observation of the internal water level.

4.5.1 Improved filter: configuration options



4.5.2 Stacked components and packaged filters Piles of 5, 10, and 15

The forms of these three components have been designed to allow for effective stacking of multiples of the same component. This will suit having the product stocked in spaza shops, as well as for transportation and shipping, making the most use of the space available in the vehicle or shipping container.



Colour variations

Covering lid and stand can be moulded in a variety of colours, the following being some of the colour options.



4.5.3 Receptacle

The receptacle forms the main body and central part of the filter, as it stores the filtered water, encases and supports the ceramic filter element and supports the lid.

The unit incorporates the existing Filtron ceramic filter element with a curved lip that prevents any unfiltered water spilled during filling from running into the filtered water below, thus preventing contamination of the filtered water.

The size of the receptacle is capable of storing a sufficient volume of filtered water to supply a family of four with two litres of drinking water each for a duration of two days. The receptacle can store 16 litres.

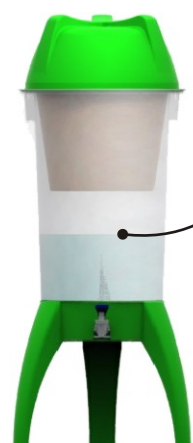
The receptacle has a bottom angles towards the spigot allowing for the maximum use of the filtered water.

The spigot has been lowered as much as possible and allows for easy assembly, while at the same time allowing for maximum filtered water usage.

The mounting hole on the receptacle into which the spigot assembles is moulded into a small flat face on the receptacle. This ensures a better seal between the silicone washer, the receptacle face and the spigot, than on the curved surface of the receptacle.

It has an incorporated circumferential rim of plastic on the base that, even with the sloped bottom, allows for the filter assembly to rest on a raised surface or table.

The receptacle has two clip mounting points, one on each side of the rim, for a bent steel hanging handle (as found on buckets). This enables the assembled filter to be suspended. The mounting points are designed to aid the stackability of receptacles, as they prevent the stacked receptacles from friction-fitting and interlocking inside one another. The lower face of the mounting point rests on the upper lip of the receptacle beneath.



Translucent Plastic:
Able to easily monitor water level.

Indentation:
Ergonomic carrying on the users head for transporting from the distributor to the home.



Angled Bottom:
Maximising water usage.

Key Form:
Aiding in assembly,
Matches the forms of the support stand.



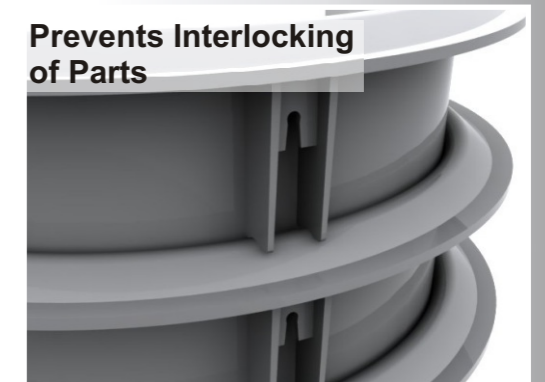
Flat Rim:
Able to be lifted at any point around circumference.

Internal Volume:
Able to hold 16 litres of water.
Enough for a family of 4 for 2 Days (2l p/p per day).

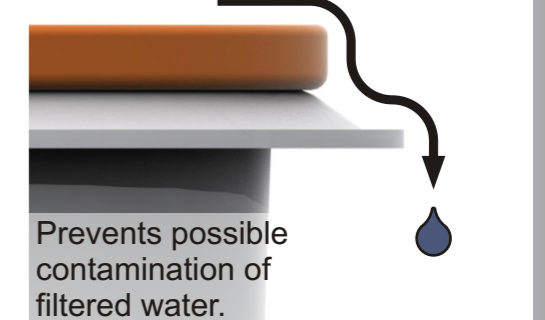
Flat Area for Spigot:
Improved spigot sealing.



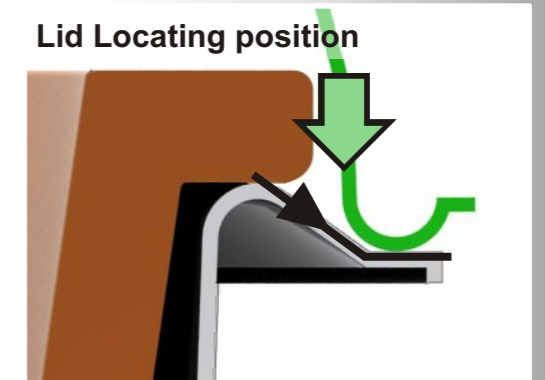
Prevents Interlocking of Parts



If Overfilled:



Lid Locating position



4.5.4 Lid

The filter includes a covering lid to prevent dirt from coming into contact with the filter element.

The lid is designed to form a seal around the lip of the receptacle to prevent dust and insects from entering the filter.

The covering lid locates evenly on the receptacle's rim, there is no need for a fastening mechanism.

The covering lid is easy to remove from the filter unit.

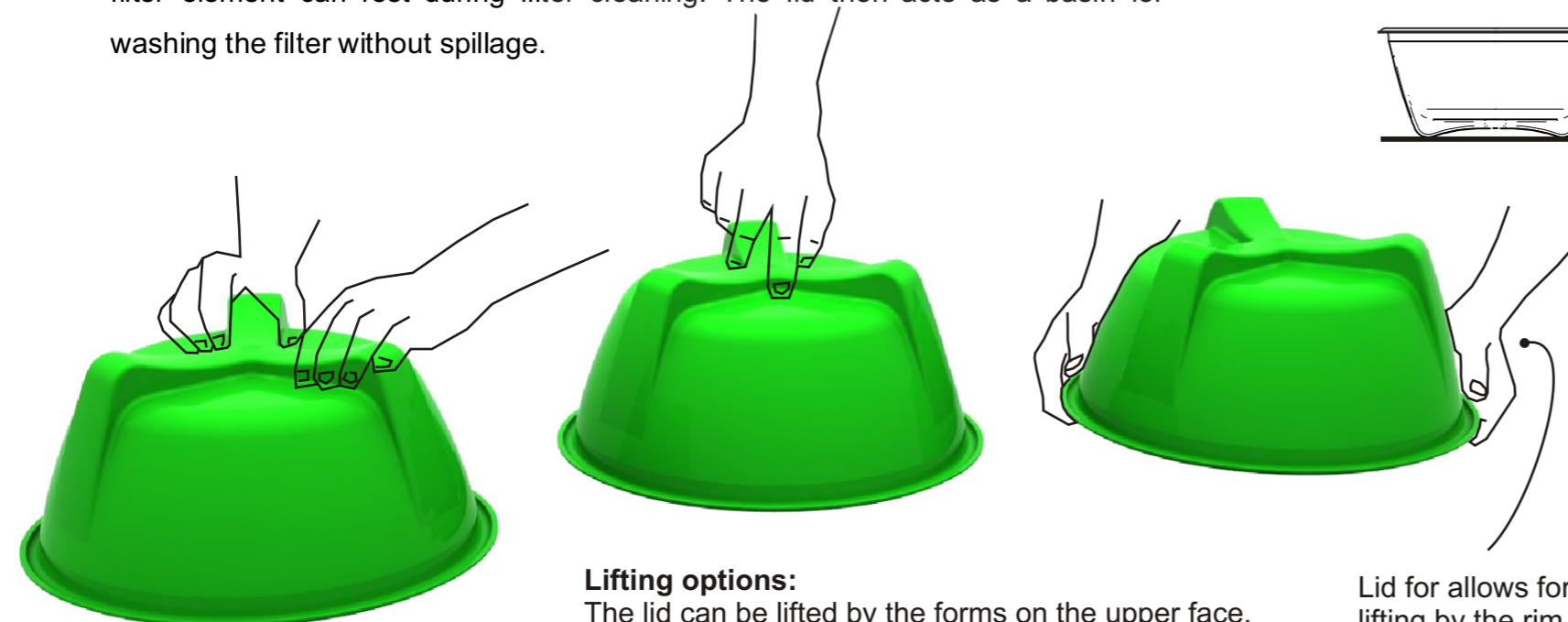
The covering lid includes three handle protrusions on its upper surface, allowing for lifting either in the centre using one hand, or nearer to the sides using two hands.

The covering lid can be lifted by these protruding forms, as well as by the rim.

The covering lid is designed to be used as a vessel for decanting the correct amount of unfiltered water into the filter element. The lid's internal volume holds slightly more than the volume of the filter element, the increased volume enables the user to move the full lid from where it has been filled without spilling.

The covering lid can be inverted and placed on a flat surface or floor and can be used as a clean surface on which the filter element rests during routine cleaning. The three handle forms on the top of the covering lid allow for the lid to remain stable on whichever surface it is placed on.

The inside of the inverted lid acts as a clean, stable surface on which the ceramic filter element can rest during filter cleaning. The lid then acts as a basin for washing the filter without spillage.



Lifting options:

The lid can be lifted by the forms on the upper face, At the center where the three forms meet, and at the rim using either 1 or 2 hands

Lid For Filling:

Lid has internal volume equivalent to that of the ceramic filter and can be used for filter filling. 1 lid = 1 fill = 8 litres.



Inside of Lid:

Filter can rest on the flat faces inside the lid during routine maintenance.



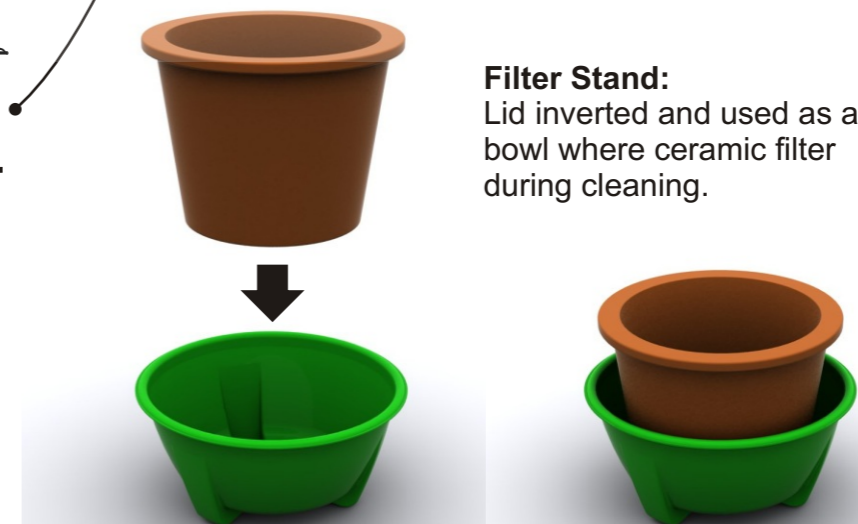
1 2 3

Three raised forms:

Allow for the lid to be used as a bowl, where the filter can rest during cleaning

Filter Stand:

Lid inverted and used as a bowl where ceramic filter during cleaning.



Lid for allows for easy lifting by the rim

4.5.5 Stand

The support stand allows for the receptacle to be supported at a predetermined comfortable height for both filling of the filter and retrieving water from the spigot.

It has three legs allowing it to rest firmly on the floor, even if the floor is uneven.

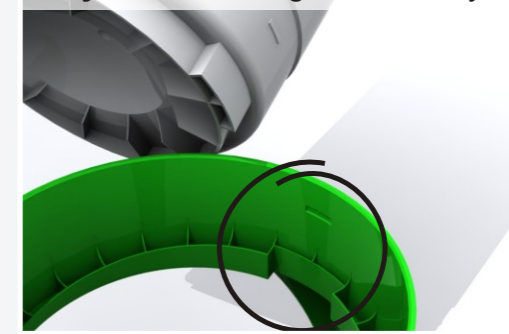
By having three legs, the legs will always be contacting the floor, and the stand would always be stable.

The legs are sprayed out from the ring of contact with the receptacle, creating a stability footprint large enough to prevent the assembled filter from being accidentally knocked over. This footprint is Ø450mm and is larger than that of the Filtron filters Ø280mm base.

The stand is designed so that the receptacle can be inserted into it. A clip holds it in place on the one side, and on the other side, the spigot is assembled to the receptacle through a hole in the stand. This is beneficial as the filter base is therefore fastened to the receptacle, allowing for the filter unit to be repositioned to another position of the household without any unnecessary filter disassembly. This locks the receptacle to the stand to prevent the receptacle accidentally separating from the stand during use.



Key Form: Aiding in assembly.



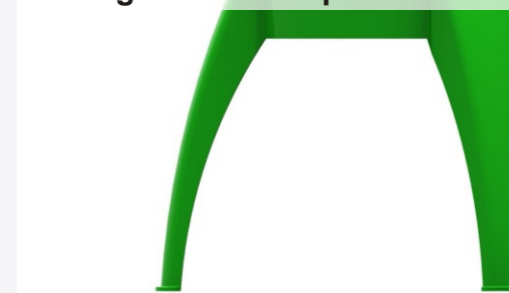
Spigot locks receptacle to stand.



Foot has included lip, providing extra strength.



Form of leg allows for sufficient strength from thin plastic.



4.5.6 Hanging handle

The wire hanging handle is a separate component that could to be supplied with the rest of the filter components, or sold separately as is.

The handle is bent from 6mm mild steel rod and will be galvanised to prevent rusting.

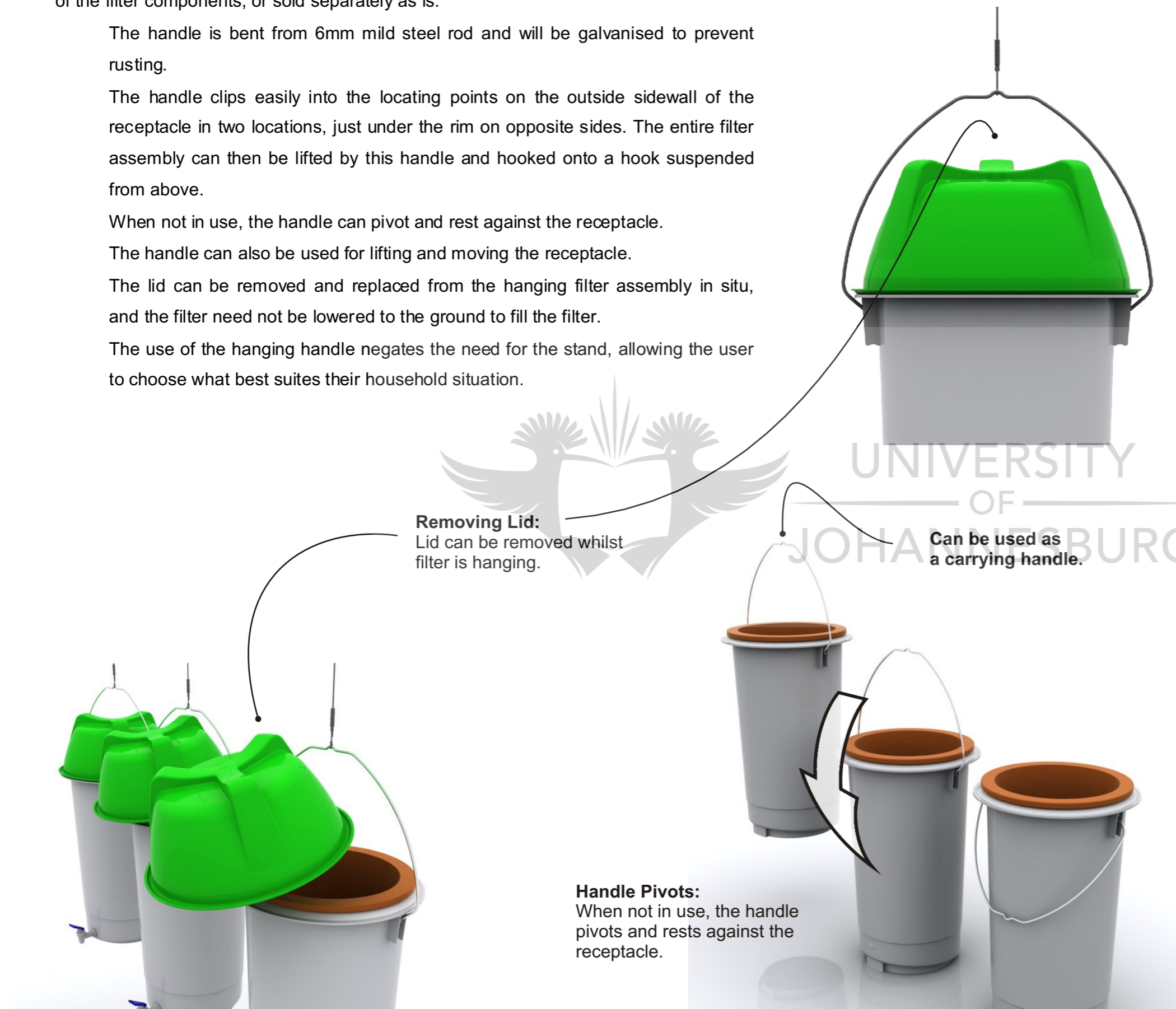
The handle clips easily into the locating points on the outside sidewall of the receptacle in two locations, just under the rim on opposite sides. The entire filter assembly can then be lifted by this handle and hooked onto a hook suspended from above.

When not in use, the handle can pivot and rest against the receptacle.

The handle can also be used for lifting and moving the receptacle.

The lid can be removed and replaced from the hanging filter assembly in situ, and the filter need not be lowered to the ground to fill the filter.

The use of the hanging handle negates the need for the stand, allowing the user to choose what best suites their household situation.



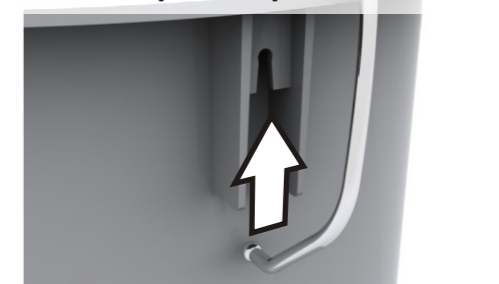
Manufacture Simplicity.
Handle is bent from 6mm steel rod



End is 'mushroomed'



Handle is pulled upwards and snaps into position.



Handle in position.



4.6 Prototypes

To assess the success of the improved filter design it was necessary to produce three-dimensional test prototypes that could be used to evaluate the proposed theory of the design physically. These constructed prototypes enabled the following to be observed:

1. The physical size of the components forming the improved filter, as well as the physical size and scale of the assembled improved filter. This relates to visual size and proportion as well.
2. The designed shape of the components, in order to assess their manufacturability.
3. By means of physical interaction with the filter model, i.e. actually using it, its stability was tested.
4. The improved filter model could be assembled and disassembled. This provided an impression of the ease of the assembly.

A typical problem of the development of mass produced products in an industrial design process, is that the final design cannot be tooled to check whether it is suitable or not. The cost involved in such an exercise would be exorbitant and if changes were required, costs would escalate. Therefore, two models were constructed to provide all the necessary information needed to assess the usability and manufacturability of the improved filter design. The first prototype was a full-size fabricated working prototype that was able to filter, store and supply water from the spigot (fig. 4.10).



Fig. 4.10 Full-size working prototype

Its covering lid could be used to support the filter element for cleaning and to decant water into the filter element. This model's main components were fabricated from ABS²¹ plastic sheeting and bonded with MEK²² solvent and super glue. It has similar rigidity and weight properties to the design if it were to be manufactured using the injection moulding process. However, this model does not replicate every design detail and is not a true visual reproduction of the final design. The second model is a half-size model which is 'grown' using a rapid prototyping machine utilising a FDM²³ process (fig. 4.11).



Fig. 4.11 Half-size rapid prototype model

This provides accurate components as they are created directly from the computer models of the improved filter design. Although half-size, the model contains details of the design to a level of accuracy or tolerance that were not present in the full-size fabricated working model. Assembly of the components accurately simulates the intended manufactured filter design.

²¹ Acrylonitrile Butadiene Styrene. Also known as ABS is a common thermoplastic used to make light, rigid, molded products.

²² Methyl Ethyl Ketone. Also known as MEK is a strong cleaning solvent also effective for welding some types of plastics.

²³ Fusion Deposition Modeling. Three dimensional models are 'grown' in 0.2mm micro slices from CAD models, using a filament of molten ABS plastic. As the filament is laid down it bonds to the previous layer producing a solid component able to accurately simulate the CAD designed components.

4.6.1 Full-size working prototype production (fig. 4.12)

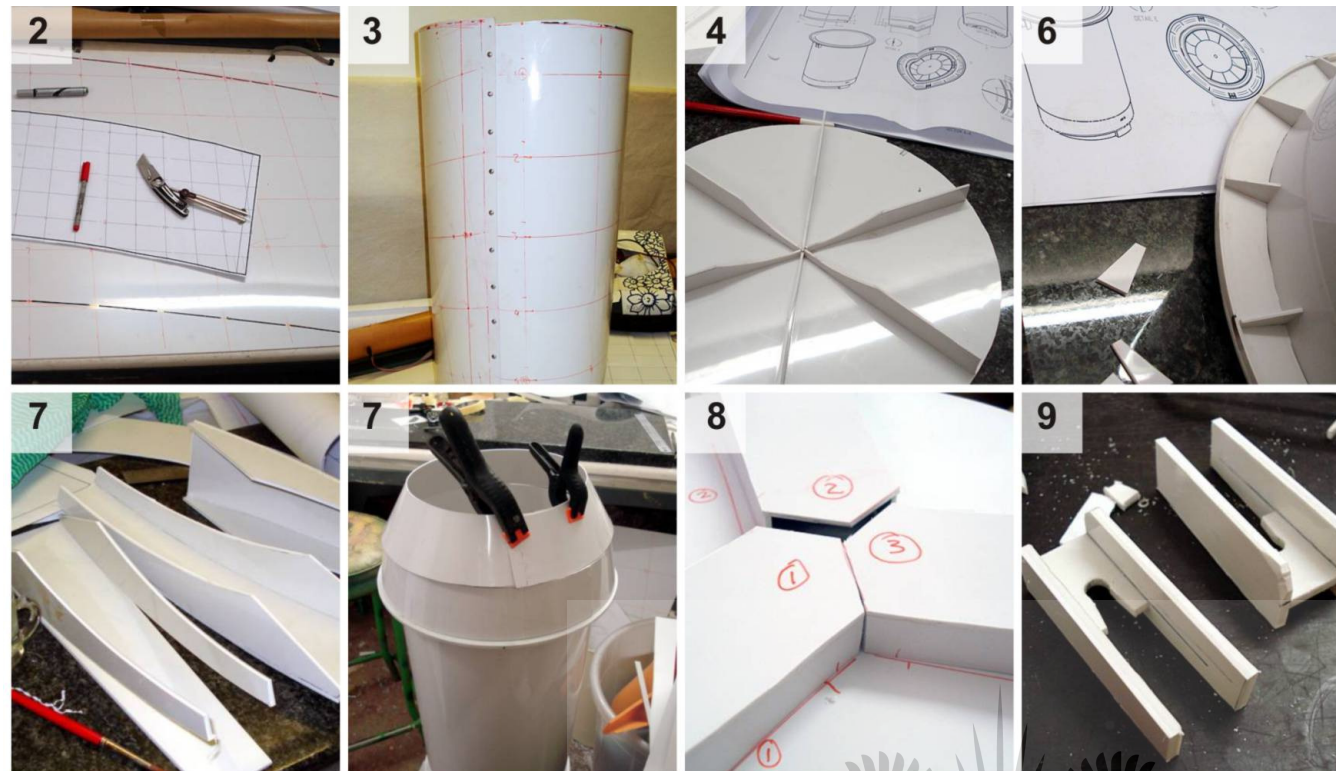


Fig. 4.12 Full-size working model production

1. 1.5 mm ABS²⁴ plastic sheeting was used for the fabricating of the working prototype. This plastic sheeting had a suitable thickness to simulate the strength properties of the intended 2 mm Polypropylene plastic in the final design.²⁵ The ABS sheet could be bent, cut, bonded and sanded as necessary to produce the forms of the improved filter design.
2. Model-makers' drawings were printed from the CAD software used to design the improved filter. These were used as templates to cut the required shapes from the ABS sheeting.
3. The receptacle form was cut and flattened in the CAD software so that the shape cut in the ABS sheeting could be rolled into form and bonded together to accurately replicate the receptacle body as a physical part.
4. The inner floor of the receptacle was cut from plastic sheeting, re-inforced with several ribs to provide rigidity and bonded into position.
5. The upper rim of the receptacle was cut into a ring, re-inforced with a strip of plastic forming a lip, and placed over the upper rim of the receptacle.

²⁴ Acrylonitrile Butadiene Styrene: a thermoplastic used in the production of various products.

²⁵ Polypropylene sheeting cannot be used for fabrication of this model as it has a high oil content, therefore bonding of this plastic is very difficult. ABS plastic, however, allows for easy bonding, sanding and shaping.

6. This upper rim was re-inforced with small bonded plastic ribs underneath its outer surface. This provided the necessary strength for the upper rim of the receptacle to hold the filter element.
7. The pattern of the support stand, stand legs, and the covering lid were designed in the CAD software in the same way as for the receptacle.
8. The handle forms of the lid were fabricated separately, and then bonded onto the lid.
9. Supports for the hanging handle were fabricated from 3 mm ABS and bonded to the receptacle wall.
10. Once the stand and the receptacle were complete and assembled, the spigot hole was cut through both. A pilot hole was first drilled to allow for accurate hole placement.
11. The metal hanging handle was bent from a section of 6 mm mild steel round bar. This metal handle could snap into position as intended in the design. The entire filter assembly could be moved and suspended from this handle.

4.6.2 Half-size rapid prototype production

A half-size model was 'grown'. If a full-size model were to be 'grown' using this machine, each component would need to be split and 'grown' in four pieces, and bonded together once complete. This would have taken much longer and increased cost greatly, for the same results that could be evaluated at half-scale. The production of the rapid prototype model was undertaken as follows:

1. Initially the CAD model's wall thicknesses were modified to suitable thicknesses²⁶. This model was then translated into a file format that the Rapid Prototyping machine needed to 'grow' the part (a stereolithography file). The rapid prototyping machine used was a Stratsys Dimension BST.
2. Each individual component was then 'grown' by the Rapid Prototyping machine which took 95 hours of 'growing'²⁷ (fig. 4.13).

²⁶ Due to the model being 'grown' at half-scale, the wall thicknesses of the parts should be 1mm. However, this would produce a very weak part. The half-size model was altered to have a wall thickness of 2mm without affecting the assembly of the components.

²⁷ 95 hours of machine time at R150/hr excl. VAT calculates to R16 245 total (27 October 2008). This was sponsored by the department of Industrial Design at the University of Johannesburg.



Fig. 4.13 Finished parts took a total of 95 hours to 'grow'

3. The components were then sprayed to portray the colours intended for manufacture. The natural colour of the 'grown' parts was white ABS. In order to observe the detailing of the components, it would be easier if the painted components were painted with a flat colour. The colour chosen for the half-size model was matt light green (fig. 4.14).



Fig. 4.14 Components sprayed to portray intended colours better

4. A wire handle was bent from 3 mm stainless steel wire (to replicate the half-scale) and attached to the model (fig. 4.14).
5. The ceramic filter element was also 'grown' at half-scale and sprayed a colour that resembled ceramic (fig. 4.14). This was not a working component.
6. The spigot was 'grown' half-scale and sprayed blue (fig. 4.14). This was not a working component.

4.7 Synopsis

The improved filter design was developed, from concept to final design. The final design was presented in three forms: Computer renderings, a full-size working prototype, and a half-size rapid prototype. By looking at the presented forms of the final design, it is possible to assess whether the improved filter represents considerable improvement from the existing Filtron filter. In the following chapter, the improvements, as well as cost implications for manufacturing the improved filter design are summarised.

CHAPTER 5: SUMMARY, RECOMMENDATIONS AND PROPOSALS FOR FURTHER RESEARCH

5.1 Summary of the improved filter design

The success of the improved filter should be assessed through testing with the intended users. However this is not possible for this study due to time constraints, monetary and logistical limitations. It could be possible to pursue this project further in the future if the improved filter were to be considered for manufacture and distribution by means of the larger point-of-use project. If this further investment were to be considered, there needs to be further input from the intended users regarding the final filter design. The improved design can however be assessed by comparing it with the list of design requirements initially compiled from all data gathered relating to the use of the Filtron filter. This can be done by studying the various presented forms of the improved filter: the CAD renderings and descriptions, the half-size rapid prototype and the full-size working prototype. Through this analysis, sufficient information will be provided to assess the improved filter design. This includes the positive aspects of the Filtron filter used in the improved filter design. As the cost of the final product is important, this too needs to be analysed. For this reason, tooling and manufacture quotes had to be obtained from various manufacturing companies, both locally and internationally.

5.2 Summary of the benefits of the Filtron filter carried through into the improved filter design

- The unit with the stand has an increased footprint, thereby making it stable.
- Receptacles are stackable.
- The covering lids are stackable.
- The chosen material from which the parts are manufactured is durable and easy to clean (food-grade Polypropylene plastic).
- The receptacle is translucent, allowing for easy observation of the filtered water level.
- The covering lid does not weigh much and is easy to lift.
- The unit is easy to assemble.
- The spigot of the Filtron filter suits its function and was used in the improved filter design.
- The ceramic filter element in the Filtron filter suits its function, is scientifically proven and was used in the improved filter design.

5.3 Cost of tooling and manufacturing of improved filter components

Tooling and production quotes were requested for all the components of the improved filter, to evaluate the value-benefit comparison to the Filtron filter. Mass production is beneficial, as all manufactured products are identical and manufacturing costs can amortise tooling costs over large runs. Quotes for the ceramic filter element and spigot were also requested, to calculate the total cost of the complete improved filter. Filter elements can be manufactured locally if the improved filter is to be developed further. This would require further research and correspondence with Potters For Peace representatives.

Spigots are available from a company in China in large quantities (100 000 units). This allows for the lowest possible unit cost.

The three main parts of the improved filter will be mass manufactured using injection moulding (annexure 23). The components have been designed to limit technical difficulties in the plastic injection tools, but due to the size of the components, the tooling costs will be high. This cost can be offset by manufacturing large quantities; the amortisation of costs for tooling across the number of units can then justify the initial outlay for these tools. Quotes were requested for the tooling and production of 100 000 units.

The remaining newly designed component on the improved filter is the wire hanging handle. These handles should be mass manufactured in galvanised mild steel, using CNC wire bending for manufacture, allows for fast production and a guaranteed quality component with tight tolerances. Quotes were requested at 100 000 units. With this manufacturing process, no tooling cost is required, allowing for lower manufactured batch sizes (annexure 23).

The cost of the improved filter was calculated and totals R228.65, including a 40% markup over the manufacturing costs (29 October 2008). This is markup takes into consideration overhead costs and profit. The total cost compared with the cost of purchase and import of the Filtron filter which totals R203.84 (29 October 2008), showing that the improved filter is slightly more expensive. The value-benefit of the new filter design should account for the additional costs.

5.3.1 Conclusion of costing

Although the improved filter is more costly to manufacture, the difference in cost is not great. All components can be mass produced allowing for the lowest possible unit costs. The tooling and manufacturing costs are approximate figures obtained from manufacturing companies and

excludes any price negotiations which could take place during price negotiations. The calculated costs of the improved filter are therefore not fixed and could be decreased. However, it gives an idea of estimated manufacturing costs and freighting costs of the parts and shows that the improved filter can be mass manufactured at a relatively low cost.

5.4 Why the improved filter is better than the Filtron filter

- The improved filter satisfies many of the design requirements the Filtron filter does not. Several of the main points are as follows:
 - Problems with placement.
 - Problem with insects accessing the filter element.
 - Ergonomics and usability of the filter.
 - Ease of use of the filter, with regards to filling and retrieving water, and cleaning procedures.
- The design is based extensively on the user's input in the research phase of the project gathered after regular use of a similar filter (the Filtron filter). However, further involvement from the users will be necessary.
- By means of the application of the industrial design process, placing the user at the centre of this process and including them in the research phase, the outcome is a functional, affordable, manufacturable and distributable product, suited to high production numbers and low unit costs. The improved design is suited to the users, as well as to the manufacturing methods able to yield high production numbers.
- The filter can operate as a free standing unit and does not rely on specific requirements in a household environment.
- The filter unit has been developed to suit African conditions, restricting dust and insects from entering the filter. Therefore preventing possible contamination sources from accessing the inside of the filter.
- Wastage has been kept to a minimum in the manufacturing process, allowing for the lowest possible unit costs. Furthermore, components of the filter fulfil several functions. The covering lid can be used for filling the filter, as well as a bowl in which the filter element can rest during cleaning procedures.

5.5 Recommendations and proposals for further research

It is recommended that further research be conducted regarding the improved water filter. This could include of the following:

- Before any additional user testing takes place it is recommended that an instruction manual specific to the improved filter be developed, providing information on correct filter cleaning and assembly instructions. This should be translated into Venda and should be as illustrative as possible, the levels of illiteracy in the Venda area needs further investigation. The general understanding of pictograms and instruction manuals needs further research.
- The potential for the improved filter to be manufactured on a batch level and re-implemented in the same villages in the Vhembe region needs to be investigated.
- User involvement regarding the Final design is needed before committing to the manufacturing of test prototypes. This can be a combination of developmental prototypes, grown prototypes, computer renderings etc.
- A prototype test batch of filters could possible manufactured and implemented into the rural households. The users would use the filters for a minimum duration, and after this trial period, further interviews could to be conducted and data-specific information on the improved filter could be gathered. This will provide conclusive evidence regarding the effectiveness of the improved filter design.
- If the improved design proved to be successful after the user testing, manufacturing and distribution could be pursued. This could be undertaken by Government or health-related NGOs implementing the filters as a water health intervention. Alternatively, the improved filter could be privately manufactured and distributed as a product for sale in spaza shops, hardware stores for rural users to purchase with additional external funding.
- If the improved filter design proves to be more suited to South African rural areas than the Filtron filter, there is the possibility that the improved filter may also be suited to other rural areas in Southern Africa, Africa, and possibly other developing nations around the world. Further research into its effectiveness in other areas could be undertaken.
- Research regarding local manufacturing of the Potters For Peace filter element should be pursued. It should be conducted with both a mass manufacturing approach as well as at community level. The effectiveness and appropriateness of the locally sourced clay as a filtration medium would need to be researched.

5.6 Relevance to institutional and national objectives

5.6.1 Relevance to national objectives

This dissertation falls in several focus areas of the National Research Foundation, and most closely fits into the following focus areas:

- Distinct South African research opportunities.
- Sustainable livelihoods and the eradication of poverty.

5.6.2 Relevance to the University of Johannesburg – community engagement

The project is based on community upliftment and improving the quality of life of the intended users. This fits into what Naledi Pandor, the Minister of Education's address at the launch of the University of Johannesburg's Faculty of Education's partnerships and the Centre of Education Practice Research Centre (UJ, 2007).

5.6.3 Relevance to the University of Johannesburg – inter-university collaborations

As this project is an inter-university collaboration between the UJ and UniVen, it promotes capacity building at a previously disadvantaged university (University of Venda). The outcome is a product which could possibly be distributed back into the disadvantaged communities that could in turn improve the quality of life in the participating communities. It also highlights the benefits that industrial design can offer faculties and universities that have not had experience in this field before.

5.6.4 Relevance to the Faculty of Art, Design and Architecture

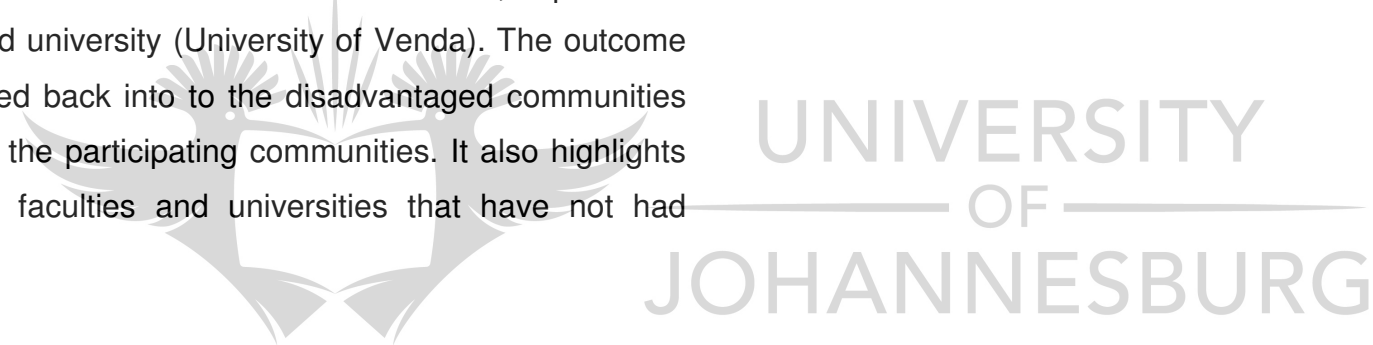
This dissertation falls under the Design for Development research focus area in FADA. The research area focuses on the inter-linked fields of research in design and products with the specific aim to be used by communities in South Africa.

5.6.5 Relevance to the Department of Industrial Design

The point-of-use project created an opportunity for the Department of Industrial Design to work in conjunction with other faculties from the University of Johannesburg (Health and Social Sciences) and the University of Venda. This opportunity promotes interdisciplinary research in the University and creates an awareness of the benefit of Industrial Design to other scientific fields.

5.7 Conclusions to the study

The outcome of this study is an improved filter which has been developed for use in rural South African households by including these households in the design process. If the living conditions in other rural areas are similar, the filter could be better suited than other filter alternatives for use in other rural areas in Southern Africa, Africa, and possibly other developing nations around the world. This could provide a water filter design that could improve the living standards of many different people by providing them with an effective, usable product suited to their living environment. Furthermore, the methodology used in this project can be applied in the development of other products for rural communities, producing outcomes suited to the user.



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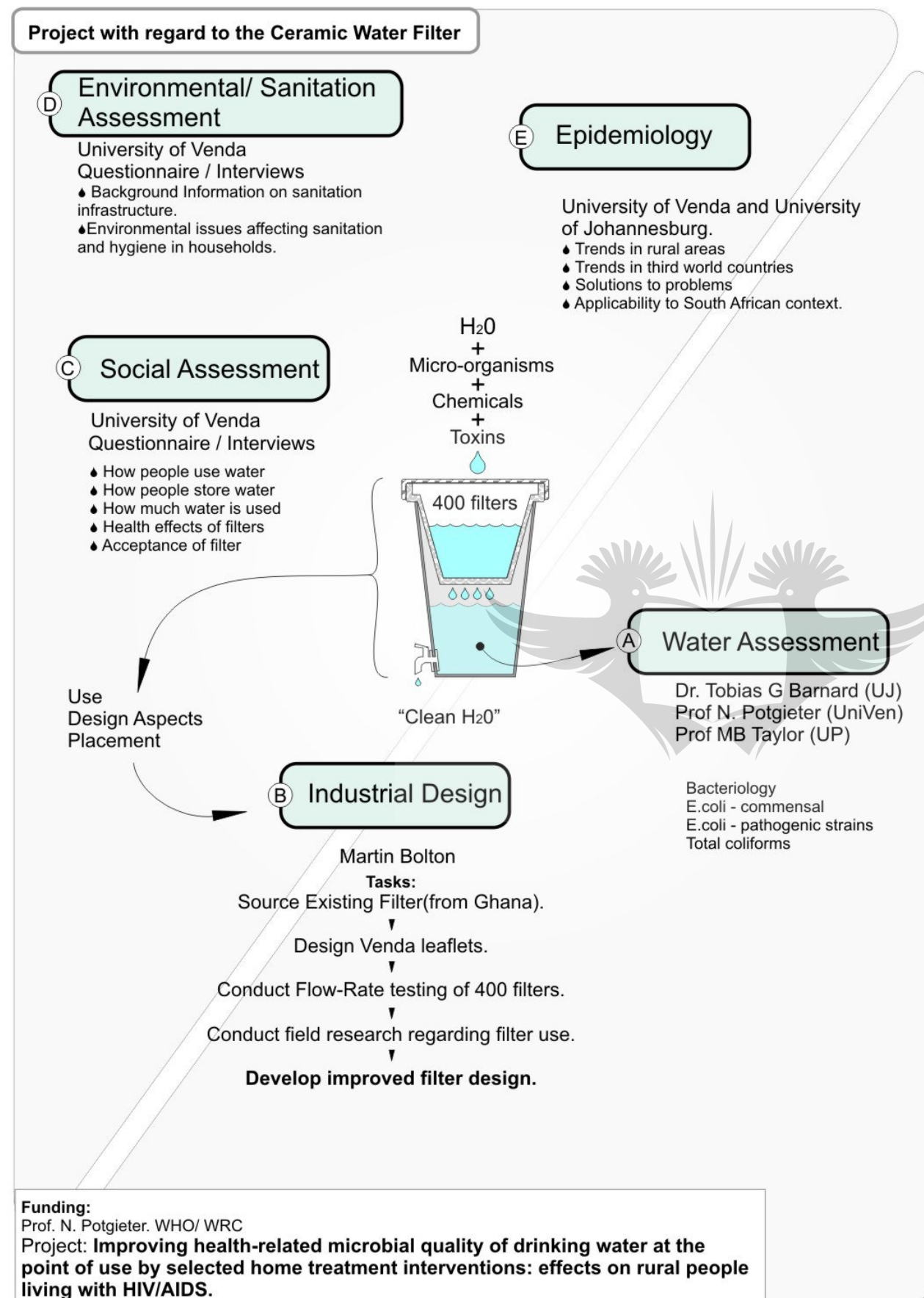
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WELLNESS GOODS. 2008b. Water Products: Terra Cotta Countertop Water Filter [Online]. Available from: <http://www.wellnessgoods.com/e2.asp> [Accessed 19/08/2008]

Annexure 1

Diagram describing the point-of-use project sections with regard to the Potpaz Water Filter.



Annexure 2

Permission to use intellectual property on the Potpaz water purifier.



Martin Bolton
Department of Industrial Design
Faculty of Art, Design and Architecture
University of Johannesburg

Permission to use intellectual property on the PFP filter system:
To whom it may concern

This is to certify that Potters-for-Peace shares the intellectual property on the Potters for Peace (PFP) Ceramic water filter to all. The intellectual property is open sourced and a copyright cannot be registered on the design. The PFP filter consists of a large plastic receptacle, into which a pot style ceramic filter is inserted, and is covered with a lid which is lifted by hand. Water is poured into the ceramic filter and gets drawn through the filter as a result of gravity. Water collects in the receptacle and is tapped through a spigot on the lower section of the receptacle.

Because Potters for Peace strives to disseminate the design of the PFP Filter as widely as possible, they relinquish any rights to the use of the intellectual property. Anyone is free to copy the design of the PFP if they wish to, and to manufacture the PFP filters according to this design, or to manufacture filters based on the PFP filter design.

The only condition is that any person manufacturing such a filter, or deriving a new design from the original design, extend the same freedoms to the general public and place no restrictions on the copying, manufacturing, or distribution of such filters.

Peace

Ron Rivera
International Coordinator
Ceramic Water Filter Program
Potters For Peace www.pottersforpeace.org
Managua, Nicaragua
tel: 505 277 3807

PFP is a Member of The International Network to Promote Household Water Treatment and Safe Storage of the World Health Organization
http://www.who.int/household_water/en/

Annexure 3

Filtron leaflet, received with the imported Filtron filter, page 1



CT

Enhancing Nature Naturally

GUARANTEE
QUALITY OF WATER IS
GUARANTEED FOR **3 yrs**
WITH PROPER HYGIENIC
HANDLING OF FILTER

Filtron

PRODUCED BY

CT
Enhancing Nature Naturally

DISTRIBUTED BY

Tel: 021 - 502219, 500505
E-mail: info@ceramicatamakloe.com
Website: www.ceramicatamakloe.com

Filtron leaflet, received with the imported Potpaz filter, page 2



HOW TO USE THE CT FILTRON

BEFORE FIRST USE

1. Attach the tap (faucet) to the receptacle if it is not attached already.
2. Wash your hands with soap.
3. Wash the inside of the receptacle (plastic container) with soap and boiled water.

FILLING THE CT FILTRON

Bucket of Source Water → Outer Cover → Inner Cover → Ceramic Filtering Element → Plastic Receptacle → Filtered Water → Tap

HOW TO CLEAN CT FILTRON

Cleaning the CLAY POT (Filtering Element)

When water filters through slower and slower it is a sign that the pores of the filter are clogged.

For washing the pot:

1. Do not lift the clay filter full of water: rims may break.
2. Wait until the filter is empty.
3. Wash your hands with soap.
4. Remove the empty clay filter from the plastic receptacle.
5. Put it on a plate that has been washed with filtered water.
6. Pour a few inches of filtered water back into the filter.
7. Scrub the filter with a stiff laundry brush on the inside to remove any debris or particles; do not worry if some of the clay comes off; it means you are scrubbing well.
8. Rinse with filtered water until the water is clear.

Cleaning the RECEPTACLE (plastic container)

Wash the receptacle once per month with water and soap as explained above (first use).

Attention: depending on the use and water quality the CT Filtron can function well up to 3 years. After this period the pot has to be replaced. For further information please contact the organization that distributed your filter, or contact **CeramicaTamakloe Ltd** 021-500505, 502219, 7011505 info@ceramicatamakloe.com

WARNING : Do not use soap nor highly chlorinated water to wash the clay filter. Filtered or normal boiled tap water is acceptable

Remember: before serving water always wash your hands and cups with soap.

Keep your filter covered at all times. Keep your filter filled; the filter will then flow faster. (1.5 to 2.5 liters per hour)

Printing: PaperPen Systems - 021 515252

Cost breakdown of imported filters.

| | |
|-----------------------------|----------------------|
| Filter cost: (400 @ \$13.3) | : \$5 332.00 |
| Forwarding Charges: | : \$ 600.00 |
| Transport and Logistics | : \$ 500.00 |
| Freight | : \$1 406.00 |
| Total: | : \$ 7 838.00 |

| | | |
|------------------------------|----------------------|-------------------|
| Filter cost: (400 at \$13.3) | : \$5 332.00 | R38 230.44 |
| Forwarding Charges: | : \$ 600.00 | R 4 302.00 |
| Transport and Logistics | : \$ 500.00 | R 3 585.00 |
| Freight | : \$1 406.00 | R10 081.02 |
| Total: | : \$ 7 838.00 | R56 198.46 |

Cost per filter once reached Louis Trichardt. (Including transporting/ freighting)
R140.49 each

Requisition form: Purchasing, and importing cost of Filtron filters.


REKVISITENFORM / REQUISITION FORM

Nommer
Number

[illegible]

| | |
|--------------------------------|--|
| NOTAS/NOTES | |
| Comice Tamalee Limited | |
| P.O. Box 14199, Newtown, Accra | |
| GHANA | |
| Contact Person: | |
| Tel no: +233-21-502219 | |
| +233-24-4804040 | |
| Fax no: +233-21-502219 | |

| | |
|---|-----------------------------|
| Fakulteit/Skool/Afdeling Faculty/School/Department | Life & Health Research Unit |
| Adres Address | John Ow Building, Room 2112 |
| | Summiten Campus |
| Kontakpersoon Contact Person | P. Kengak |
| Gemagtigde handtekening Approved Signature | <i>[Signature]</i> |
| Tel Nr. Tel No | (011) 066 2582 |
| Datum Date | 18/01/2007 |



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JOHANNESBURG

Koste Sentrum/Cost Centre
 WHO Report 2006

Annexure 6

Instruction leaflet 1, designed by M. Bolton. Supplied to households upon implementation of the Filtron filter. English version.

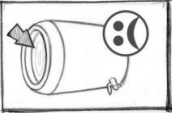
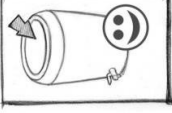


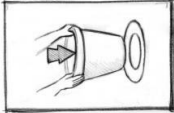
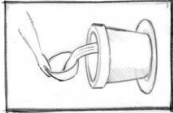
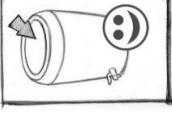
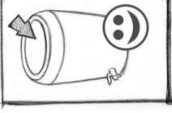



HOW TO TAKE CARE OF THE FILTER.

This will show you how to clean the clay pot and the bucket of the filter.

CLEANING THE CLAY POT.

Clean the clay pot when it filters too slowly.



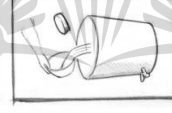




- 1. Empty the clay pot.**
Do not lift the clay pot if there is still water inside.
The pot can break if you lift it when it is still full of water.
- 2. Wash your hands.**
Wash your hands with soap and water.
- 3. Lift the pot.**
Lift the clay pot with both hands.
Hold the pot by the rim.
- 4. Place the pot on a plate.**
Put the pot on a clean plate which has been washed with soap and water.
- 5. Pour ½ litre of water back into pot.**
Pour half a litre of filtered water back into the pot.
This water will be used for cleaning the pot.

CLEANING THE BUCKET.

Clean the bucket once a month.

- 1. Wash your hands.**
Wash your hands with soap and water.
- 2. Remove the clay pot.**
The clay pot must be out of the bucket.
Lift the clay pot and place it on a clean plate.
- 3. Wash the inside of the bucket.**
Wash the inside of the bucket with soap and filtered water.
- 4. Rinse the bucket well.**
Throw out the water.
Rinse with filtered water a few times, to get all the soap out.

Annexure 7

Instruction leaflet 1, designed by M. Bolton. Supplied to households upon implementation of the Filtron filter. Translated Venda version.

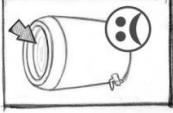
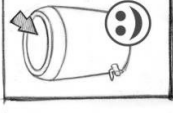


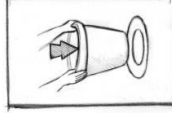
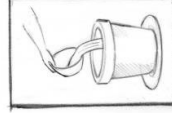
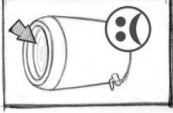
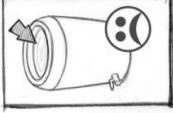


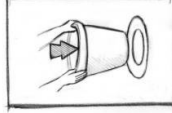
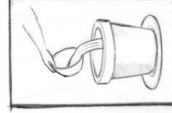
VHA NGA THOGOMELA HANI TSHITUDO

Hezwi zwi do vha sumbedza uri vha nga tanzwa hani khali na bakete la u tuda.

U TANZWA KHALI

Kha vha tanzwe khali musi i tshi khou tuda nga u ongolowesa.



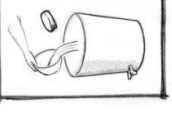

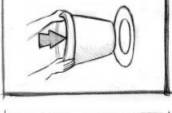
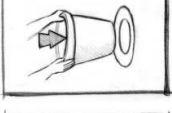
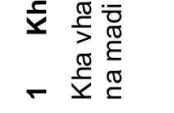
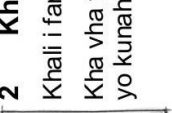
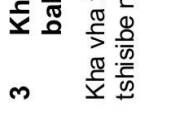
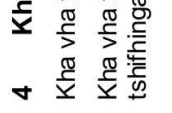
- 1 Kha vha shulule khali**
Vha songo takula khali arali hu tshi kha di vha na madi ngomu.
Khali i nga pwashea arali vha nga i takula i tshi kha di vha tsho dala nga madi.
- 2 Kha vha tambe zwanda zwavho**
Kha vha tambe zwanda zwavho nga tshisibe na madi.
- 3 Kha vha takule bodo**
Kha vha takule bodo nga zwanda zwothe
Kha vha fare bodo nga lubomo.
- 4 Kha vha vhee bodo kha phuleithi**
Kha vhee bodo kha phuleithi yo kunaho yo tanzwiwaho nga tshisibe na madi.
- 5 Kha vha shele hafu ya litha ya madi ngomu bodoni**
Kha vha shele hafu ya litha ya madi o tudiwaho ngomu bodoni
Haya madi a do shumiswa kha u tanzwa bodo.

KHA VHA TANZWE BAKETE

Kha vha tanzwe bakete luthihi nga nwedzi.

- 1 Kha vha tambe zwanda zwavho**
Kha vha tambe zwanda zwavho nga tshisibe na madi.
- 2 Kha vha bwise khali**
Khali i fanela u vha nnda ha bakete.
Kha vha takule khali vha i vhee ntha ha phuleithi yo kunaho.
- 3 Kha vha tanzwe nga ngomu ha bakete**
Kha vha tanzwe nga ngomu ha bakete nga tshisibe na madi o tudiwaho.
- 4 Kha vha tukise bakete zwavhudi**
Kha vha tevhulele madi kule.
Kha vha tukise nga madi o tudiwaho tshifhanyana, u bvisela tshisibe tshothe nnda.

Annexure 8

Instruction leaflet 2, designed by M. Bolton. Supplied to households upon implementation of the Filtron filter. English version.

FIRST TIME USING THE FILTER.



Always lift the filter by the rim. Use both hands when lifting the filter.

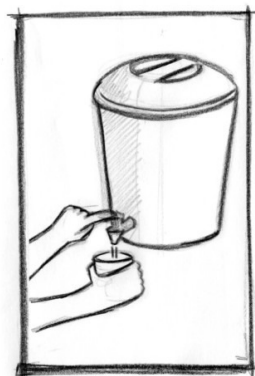


Filter a few times until the filtered water has no sandy taste or smell.



If water is muddy - Strain water through a piece of fine cloth.

You can tie the cloth around the top of the filter.



Always keep the lid on the filter.

If you keep the filter full - it will filter water faster.

Always wash your hands and cups with soap and water before serving water.

Annexure 9

Instruction leaflet 2, designed by M. Bolton. Supplied to households upon implementation of the Filtron filter. Translated Venda version.

TSHIFHINGA TSHA U THOMA U SHUMISA TSHITUDO.



Tshifhinga tshothe kha vha takusele tshitudo ntha nga lubomo. Kha vha shumise zwanda zwothe musi vha tshi takusela ntha tshitudo.

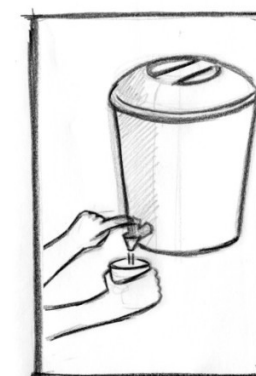


Kha vha tude tshifhinganyana u swikela madi o tudiwaho a si tsha vha na muthetshelo wa mutavha kana munukho.



Arai madi a na matope-Kha vha sefe madi nga luvhamba lwa labi.

Vha nga vhofha labi u mona na lubomo lwa tshitudo.



Tshifhinga tshothe kha vha dzule vho tiba tshitibo kha tshitudo

Arali vha tshi dzula vho dadza tshitudo - tshi do tuda madi nga u tavhanya.

Tshifhinga tshothe kha vha tambe zwanda zwavho na dzikhaphu nga tshisibe na madi musi vha sa athu shumisa madi.

Annexure 10

Self-assessment form, designed by M. Bolton. Collected from implementation households on a weekly basis, ongoing for duration of study (3 months). English version.

Household code: _____

Start date: _____

End date: _____

Name of household: _____

| Self Reporting Filter Form | eg | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|----|--------|---------|-----------|----------|--------|----------|--------|
| Where did you get your water from | | | | | | | | |
| Tap | | | | | | | | |
| Borehole | | | | | | | | |
| River Canal | | | | | | | | |
| Spring | | | | | | | | |
| When did you clean the bucket? | | | | | | | | |
| Wash hands with soap | | | | | | | | |
| Wash inside of bucket with water | | | | | | | | |
| Wash inside of bucket with soap and water | | | | | | | | |
| Rinse bucket | | | | | | | | |
| When did you clean the clay pot? | | | | | | | | |
| Wash hands with soap | | | | | | | | |
| Wash plate | | | | | | | | |
| Scrub inside of pot with brush | | | | | | | | |
| Rinse pot | | | | | | | | |

Annexure 11

Self-assessment form, designed by M. Bolton. Collected from implementation households on a weekly basis, ongoing for duration of study (3 months). Translated Venda version.

Nomboro ya mudi: _____

Mathomo: _____

Magumo: _____

Thoho ya Tshitentsi: _____

| Fomo ya udi vhigela ngaha tshitudo | Tsumbo | Musumbutwwo | Lavhuvhili | Lavhuraru | Lavhuna | Lavhutano | Mugivhela | Sondaha |
|---|--------|-------------|------------|-----------|---------|-----------|-----------|---------|
| Vho Kalwana ngafhi madi avho | | | | | | | | |
| Phaiphi/Bommbi | | | | | | | | |
| Gwedzho | | | | | | | | |
| Mulambo kana Mugero wa madi | | | | | | | | |
| Tshisima | | | | | | | | |
| Ndi lini he vha tanzwa ravha/bakete? | | | | | | | | |
| Tambani zwanda nga tshisibe | | | | | | | | |
| Tanzwani ngomu ha ravha/bakete nga madi | | | | | | | | |
| Tanzwani ngomu ha ravha/bakete nga tshisibe na madi | | | | | | | | |
| Tukisani ravha/bakete | | | | | | | | |
| Ndi lini he vha tanzwa tshitudo tsha vumba? | | | | | | | | |
| Tambani zwanda nga tshisibe | | | | | | | | |
| Tanzwani phuleithi | | | | | | | | |
| Fhalani ngomu ha tshitudo nga bulatsho | | | | | | | | |
| Tukisani tshitudo | | | | | | | | |

Annexure 12

English version of informed consent form for use during field visits.

Sheet 1 - English version.

Ref No. (1)_____

Project Information & Informed Consent Form.

Martin Bolton, University of Johannesburg, Masters Degree Project.

My name is Martin Bolton. I am a student at the University of Johannesburg. For my studies at the university, I want to make a model of a new water filter. I want this filter to be easier to use than the one which was given to you. The filter which you have is called a Potpaz filter which was brought from Ghana, in the Africa.

It is part of my studies to understand how you use the Potpaz filter and what you think of it. I want to know if you think the Potpaz filter is easy to use or difficult to use. Your opinion will help me see where there may be things that can be changed to make the new filter easier to use. If the new filter is easy to use, then people will be more willing to use it and have good quality water. If the filter is difficult to use, then people would prefer to not use it. I want to see if the filter can be made in South Africa, and if it can it will then provide jobs for people.

I need your permission to use the information which you give me to use in my studies. The information which I need will be gathered by me asking you questions with the help of a Venda speaking interviewer. I also want your permission for me to take photos of your kitchen, your house and the objects around your house. I will be getting information from several people, this will show me if different people have the same opinion about the filter. I will only ask you these questions once.

Questionnaires:

I will ask you questions about where you keep your filter, how you use the filter, and if there are any problems which you have with using the filter.

Photographs:

I will take photos of your kitchen, your house and objects around your house so that when I read your questionnaire I can also look at the photos.

Ethical considerations for your consent.

- You are under no obligation to take part in providing information for this project. If you feel that you do not want to take part, you are free to decline and will not be included in the project.
- You are free to ask any questions at any time, about the project.
- Your details will be kept confidential if you want them to be.
- No monetary compensation is offered for your participation.

I now request you to participate in my project:

Respondent's response:

- I have heard the proposed activities of the project. The activities are clear to me;
- I was provided the opportunity to ask questions;
- I have not been pressurised to participate in any way;
- I understand that participation in this research project is completely voluntary;
- I understand that I will not receive any monetary compensation for my participation;
- I am fully aware that the information gathered will be used for research purposes in the designing of a new water filter and this information may be published. I agree to this, provided my privacy is guaranteed, if I so wish.

- I hereby consent to participate in this study.

Name of respondent

Signature

Place

Date

Statement by interviewer:

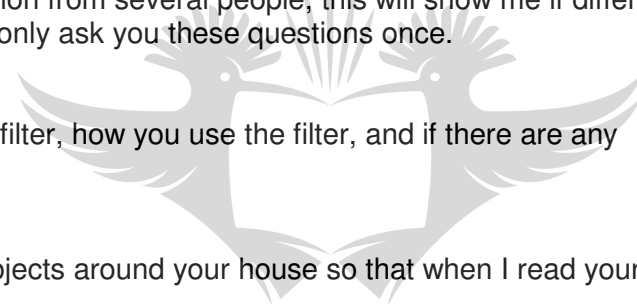
I have provided verbal information regarding this Research Project. I agree to answer any questions from the respondent concerning the Project as best as I am able.

Name of interviewer

Signature

Place

Date



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Annexure 13

Translated Venda version of informed consent form for use during field visits.

Sheet 1 - Venda version.

Ref No. (1)_____

Thalutshedzo ya thandela na fomo ya thendelo. Project Information & Informed Consent Form.

Martin Bolton, University of Johannesburg, Masters Degree Project.

Dzina langa ndi Martin Bolton. Ndi mutshundeni kha yunivesithiy ya Johannesburg. Kha funzo dzanga yunivesithi, ndi tama ubveledza mondele muswa wa u sefo madi. Ndi tama uri iyi sefo ivhi khwine ufhirisa yo netshezwaho. Sefo ine vha vha nayo ipfi "Potpaz filter" yeya rengiwa ubva "Ghana", kha la Afurika.

Ndi tshipinda tsha ngundo dzanga kha upfesesa uri vha shumisa hani iyi sefo "Potpaz" na uri vha humbulani ngayo. Ndi tama undivha arali vha tshihumbula uri iyi sefo zwoleluwa kana zwiakonda u ishumisa. Mihumbulo yavho ido nthusu uvhona uri huna zwithu zwiswa zwine zwunga itwa uri ishumisee lwa khwine. Arali sefo ntswa zwi tshileluwa u ishumisa, vhatu vhado takalela u ishumisa na u vha na madi o kunaho. Arali sefo ntswa zwi tshikonda u ishumisa, vhatu a vhanga do takalela u ishumisa. Ndi tama uvhona arali sefo l tshinga bveledzwa kha la Afurika Tshipembe, na unga bveledza mishumo kha vhatu.

Ndi humbela thendelo yavho u shumisa muvhigo we vha nnea kha ngundo dzanga. Muvhigo uyu ndi tama u ukuvhanganya nga uvhudzisa mbudziro na nga thuso ya muvhudzisi a Ambato Tshivenda. Ndi tama hafhu u wana thendelo yavho u foda zwinepe ngomu tshitanga, nnduni yavho na murahu ha ndu dzavho. Ndi do kuvhanganya muvhigo kha vhatu vho fhambanaho, izwi zwido ntsumbedza kharali vhatu fhambana vhana kuhumbulele kwo fhambanaho. Ndi do vha vhudzisa idzi mbudziro luthihi.

Dzimbudziro:

Ndi do vhudzisa mbudziro ngaha hune vha vhea hone sefo dzavho, vha shumisa hani sefo dzavho, na u divha arali hu na thaidzo kha ku shumisele kwa dzo.

Ufoda:

Ndi do foda zwinepe tshitangani tshavho, ngomu nnduni na murahu ha dzinndu uri musi ndi tshi vhala mbudziro ndi sedze na kha tshinepe.

Milayo malungana na thendelo yavho.

- A vhaho fhasi ha mulayo kha u dzhenela ngudo. Arali vha tshi pfa uri vha nga si vhe tshipida tsha ngudo vho vhofoholowa u nga dibvisa tshifhinga tshinwe na tshinwe nahone mafhungo avho ha nga do dzheniswa kha mvelelo dza ngudo;
- Kha vhapfe vhofoholowa uvhudzia mbudziro tshifhinga tshinwe na tshinwe, nga kha thandela.
- Zwindondombezwa zwa vho zwido vha zwa tshiphiri.
- A hu na ndiliso ya tshedele ine vha do badelwa nga u dzhenela havho.

Zwino ndi humbela unzhenela havho kha thandela iyi:

Phindulo ya mufhinduli:

- Ndo pfa nga mishumo yo gaganywaho ya thandela. Mishumo i khagala kha nne;
- Ndo netshedzwa tshikhala tsha u vhudzisa dzimbudziro;
- A tho ngo kombetshedzwa u dzhenela nga ndila inwe na inwe;
- Ndi a pfesesa uri u dzhenela kha Thandela ya Thodisiso heyi ndi ya u dinetshedza tshothe;
- Ndi a pfesesa uri a thi nga do wana inwe ndiliso ya tshedele kha u dzhenela hanga;

- Ndi a talukanya tshothe uri mvelelo dza Thandela hedzi dzi do shumiswa kha ndivho ya zwa saintsi nahone dzi nga andadzwa. Ndi a tenda kha hezwi, tenda tshidzumbi tshanga tsho fhulufhedziswa;
- Ndi nea thendelo hafha kha u dzhenela kha heyi thandela.

Dzina la mufhinduli

Tsaino

Fhethu

Datumu

Tshitatamennde nga muvhudzisi

Ndo netshedza mafhungo nga u tou amba zwi tshi elana na Thandela ya Thodisiso. Ndi a tenda u fhindula mbudziro inwe na inwe i bvaho kha mufhinduli i elanaho na Thandela nga hune nda kona ngaho. Ndi do nambatela kha kuitele kwo themendelwaho.

Dzina la muvhudzisi

Tsaino

Fhethu

Datumu

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Annexure 14

English version of questionnaire for use during the conducting of interview schedules.

Sheet 2 – English version.

Ref No. (2)_____

Questionnaire: for Households and Focus Group meetings.

Martin Bolton, University of Johannesburg, Masters Degree Project.

Household questionnaire: ☐

Name: _____ (Optional)

Date: _____

Village name: _____

Number of people in household: _____

Placement of filter.

- 1) Where do you place the filter?
- 2) Has the filter been knocked over?
- 3) Have you found any problems with how stable the filter is?

Lifting the lid.

- 4) How do you hold the covering lid when you lift it off of the bucket and filter?

Filling the filter.

- 5) How do you fill the ceramic filter with water? (Scooping water from large drum, or pouring water from a 20/25 litre water container)
- 6) Who makes sure that the filter has enough water?
- 7) Are there any problems which you have when filling the ceramic filter?

Getting water from filter & operating the tap.

- 8) Do you use a specific container to take clean water from the filter's tap, or do you use different containers?
- 9) What container do you use?
- 10) Have you found any problems with filling your container from the filter's tap?
- 11) Does the filter's tap leak water?
- 12) How do you hold the container and open the filter's tap? (Do you use one or two hands?)
- 13) Does the filter's tap give water fast enough?

Water quality.

- 14) Do you like the taste of the filtered water?
- 15) Is there a difference between the filtered water's taste compared to unfiltered water?
- 16) What is the difference?

Cleaning the filter/ bucket, etc.

- 17) How do you empty the ceramic filter before you lift it out of the bucket?
- 18) Do you have any problems with lifting the ceramic filter out of the bucket?
- 19) Before you clean the inside of the plastic bucket, what do you do with all the water that is left inside?
- 20) How do you clean the inside of the plastic bucket?
- 21) Do you have any problems or irritations with cleaning the ceramic filter?
- 22) Do you have any problems or irritations with cleaning the plastic bucket?

Other questions.

- 23) What things do you think can be changed on the filter to make the filter easier to use?
- 24) Has anything been broken on the filter while you were using it?
- 25) Does the filter provide enough water for everyone in your family?

Annexure 15

Translated Venda version of questionnaire used during the conducting of interview schedules.

Sheet 2 – Venda version.

Ref No. (2)_____

Mbudziso: dza Mudini na Gurupu ya watu.

Questionnaire: for Households and Focus Group meetings.

Martin Bolton, University of Johannesburg, Masters Degree Project.

Mbudziso dza Mudini:
(Household questionnaire) ☐

Dzina (Name) _____ (Otoufunu)

Duvha (Date) _____

Dzina la muvhudu (Village) _____

Nomboro ya vhatu mudini _____

(Number of people in household)

Mbudziso kha Mutangano wa Gurupu:
(Focus Group Meeting Questionnaire) ☐

Nomboro ya vhadzheneleli

(Number of participants) _____

Dzina la muvhudu (Village) _____

Duvha (Date) _____

Kuvhetshela kwa Tshitundo:

- 1) Vho vhea ngayi tshitundo yavho?
- 2) Itshi tshitundo tshono ndi vhuya tshawo?
- 3) Vhono vhuya vha vhana vhu thanda nga kudzulele kwa tshitudo?

U hwala tshitimbo:

- 4) Vhafarisa hani tshitimbo musi vhatshi tshibvisa kha tshitundo?

U ndadzwa tshitundo:

- 5) Vha ndadza hani khali ya usefa nga madi? (nga tshikelelo ubva kha doromu, kana ushela madi ubva kha tshigubu 20/25 tsha madi)
- 6) Ndi nnyi ane a thongomela uri tshitundo tshina madi olinganaho?
- 7) Huna thaidzo musi vha tshishela madi kha khali ya vumba?

U wana madi kha sefo na kushumisele kwa thepe:

- 8) Vha shumisa tsha ukelela tshokhetheaho uka madi avhudi ubva kha thepe, kana vha shumisa zwa ukelela zwofhambanaho?
- 9) Vha shumisa tshaukelela tshifhiho?
- 10) Vhono di tangana na thaidzo thepe musi vha tsh khou kelela madi?
- 11) Thepe yavho ibvidisa madi?
- 12) Vha farisa hani tshikelelo na ubvulela thepe? (Vhashumisa tshanda tshithihi kana zwivhili?)
- 13) Thepe i bvisa madi olinganaho nga utavhanya?

Vhuvhudi ha madi.

- 14) Vha au takalela mutshelo wa madi o sefiwaho?
- 15) Huna phambano vhukati ha osefiwaho na a songo sefiwaho?
- 16) Phambani ya hone ndi ifhio?

Ukunakisa sefo/liravha(Bakete), na zwinwevho.

- 17) Vha shululisa hani madi kha sefo phanda ha musi vha tshitshitakula kha liravha(Bakete)?
- 18) Vhana na thaidzo kha u wala sefo ubva kha liravha(bakete)?
- 19) Phanda ha musi vhasaathu ukunakisa bakete ngomu, vha itamini nga madi osalaho ngomu halo?
- 20) Vha tanzwa hani liravha (Bakete) ngomu hayo?
- 21) Vhana thaidzo kana usafarea zwavhudi nga u tanzwa sefo?
- 22) Vhana thaidzo kana usafarea zwavhudi nga u tanzwa liravha (Bakete)?

Dzinwe mbudziso.

- 23) Ndi zwini zwithu zwine zwinga shandukisiwa kha tshitudo uita uri tshileluwe u shuma?
- 24) Huna tshinwe tshithu tshe tsha kwashea kha tshitudo zwezwi vha tshi khou tshishumisa?
- 25) Itshi tshitundo tshi sefa madi alinganaho vhatu vhothe nga hayani?

Annexure 16

Additional questions asked in conjunction with the interview schedule.

Additional Questions

#

Martin Bolton, M-Tech Student, Industrial Design Department, University of Johannesburg.

1. Do you always fill the filter every day?
2. What time of the day do you fill your filter?
3. How many times do you fill the filter per day?
4. If there is no water in the filter, where do you drink water from?
5. How often do you drink from your household container? (unfiltered water)
6. If you could have the filter sitting at any height, what do you think would be best?

Annexure 17

Personal observation sheet completed by each household visited during the conducting of field research.

Personal Observations to be conducted
Households

#

Martin Bolton, M-Tech Student, Industrial Design Department, University of Johannesburg.

House code:

Village:

Date visited:

Time:

📍 - Specific photograph

1. Where is the purifier kept? 📍
2. What surface is it placed on? 📍
3. Is this surface part of the cooking area, or has it been specifically constructed for the purifier? 📍
4. If the surface has been constructed, from what and how was it constructed? 📍
5. How high is this surface from the floor? 📍
6. Is purifier in operation?
7. How does the rural person get water from the purifier, i.e. stoop down, bend back, or stand up straight?
8. Where is the purifier in relation to water storage source? 📍
9. Is the position of the purifier the best possible position for it within the cooking or food preparation area?
10. Is purifier kept covered?
11. Does the purifier look clean?
12. Does purifier look correctly maintained?
13. Are there any alterations made to the purifier? If so - what changes, and for what possible reasons? 📍
14. Are any parts of the purifier damaged or broken? If so, what, and possible reasons why? 📍
15. Any other comments?

Martin Bolton

Signature of observer

Annexure 18

Personal observation sheet completed at each spaza shop visited during the conducting of field research.

Personal Observations to be conducted

Spaza Shop

#

Martin Bolton, M-Tech Student, Industrial Design Department, University of Johannesburg.

Spaza Shop: _____
 Village: _____
 Date visited: _____
 Time: _____

☒ - Specific photograph

Spaza shop:

7. Are shelves overly stocked? How much shelf space is available? ☒
8. Are there any other products similar in form and size to Potpaz filter? List and explain relevance and cost. ☒
9. If improved filter were to be stocked in shelving space, what dimensions would be most suitable? ☒

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Martin Bolton
 Signature of observer

Annexure 19

Variations of the Potpaz ceramic filter (PFP, 2006d:4)

Ceramic filter variations:

(PFP Filter Update, May 2007: 4)



Standard form

Resembling a Flower-pot
 Manufactured in various countries: Mexico; Guatemala; Hondural; El Salvador; Nicaragua; Cuba; Haiti; Ghana; Sudan; Sri Lanka; Bali; Cambodia; Nepal; Bangladesh.



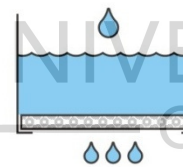
Conical Form

Spin off from standard form, conducted at a filter production facility in the Dominican Republic, initiated in 2007. Production of this filter variation is also being conducted in Uganda, Central Africa, and Honduras, Central America.



Round Bottom

Variation from standard form with a rounded bottom. In Myanmar, Southeastern Asia, over 1000 of this variation have been sold.

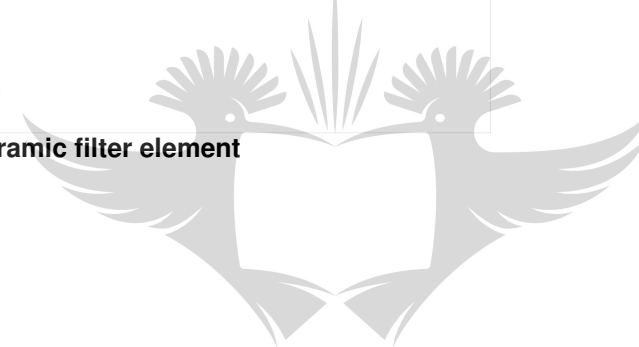
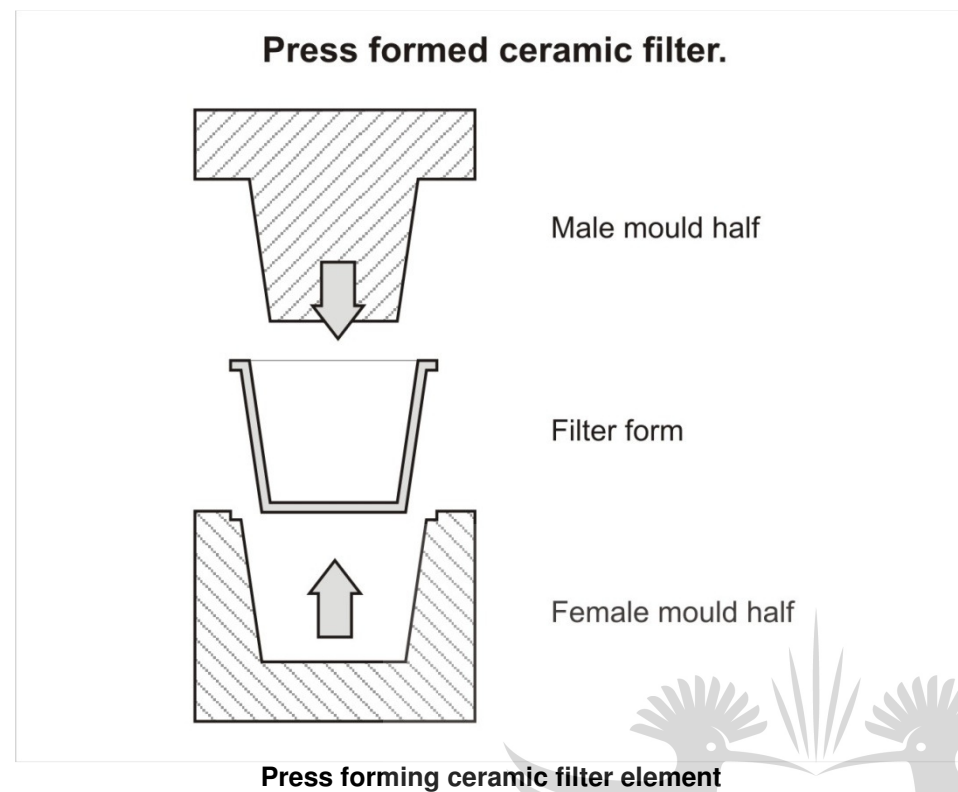


Disc Filter

Solutions benefitting life has began making disc filters in India and Nepal as they found the standard form to be too cumbersome.

Annexure 20

Manufacturing of the Potpaz ceramic filter



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According to the production manual available on the Potters For Peace website, the following steps taken are taken in the manufacture of the Potters For Peace water filter at a facility which can produce 50 filters per day (Potters For Peace, 2007e):

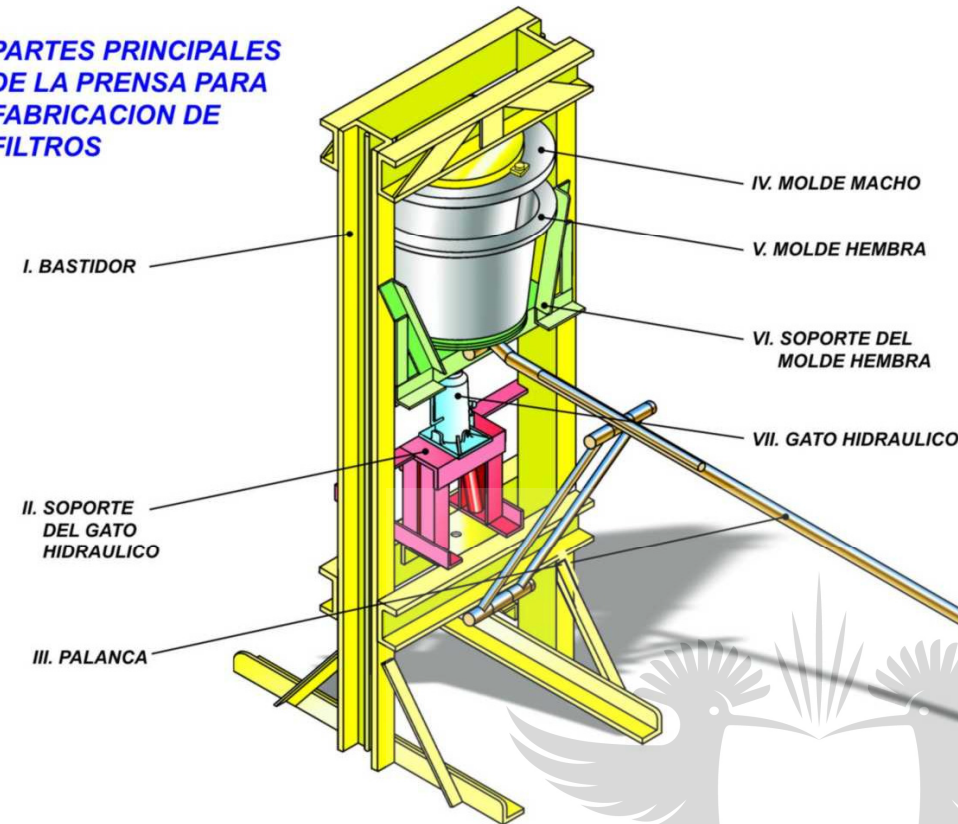
1. Clay is sourced, and allowed to age for several weeks, improving properties.
2. Clay is crushed into small enough pieces to be fed into the hammer mill.
3. The hammer mill (originally used for grinding maize) is used to crush the clay into a fine powder.
4. Dried, milled clay is stored in cloth sacks for future use.
5. Clay powder is mixed with fine sawdust at a ratio of 1 part clay to 1.5 parts sawdust (by volume).
6. Prepared powder mix is then put into the cement mixer, where water is added.
7. The prepared clay mix is then cut into suitable size parts to be formed into filters.
8. The prepared clay is put into the hydraulic press-form mould and gets formed into the filter form (refer to fig.3.17).
9. Moulded filter is carefully removed
10. Filter gets touched up and placed onto drying racks and then fired in the kiln
11. Filtration rate of filters is then checked to observe whether or not the filter is acceptable.
12. Filter is then ready for distribution, assembly and implementation.

Annexure 21

Press construction diagrams. <http://pottersforpeace.org/wp-content/uploads/press-construction-diagrams.pdf>

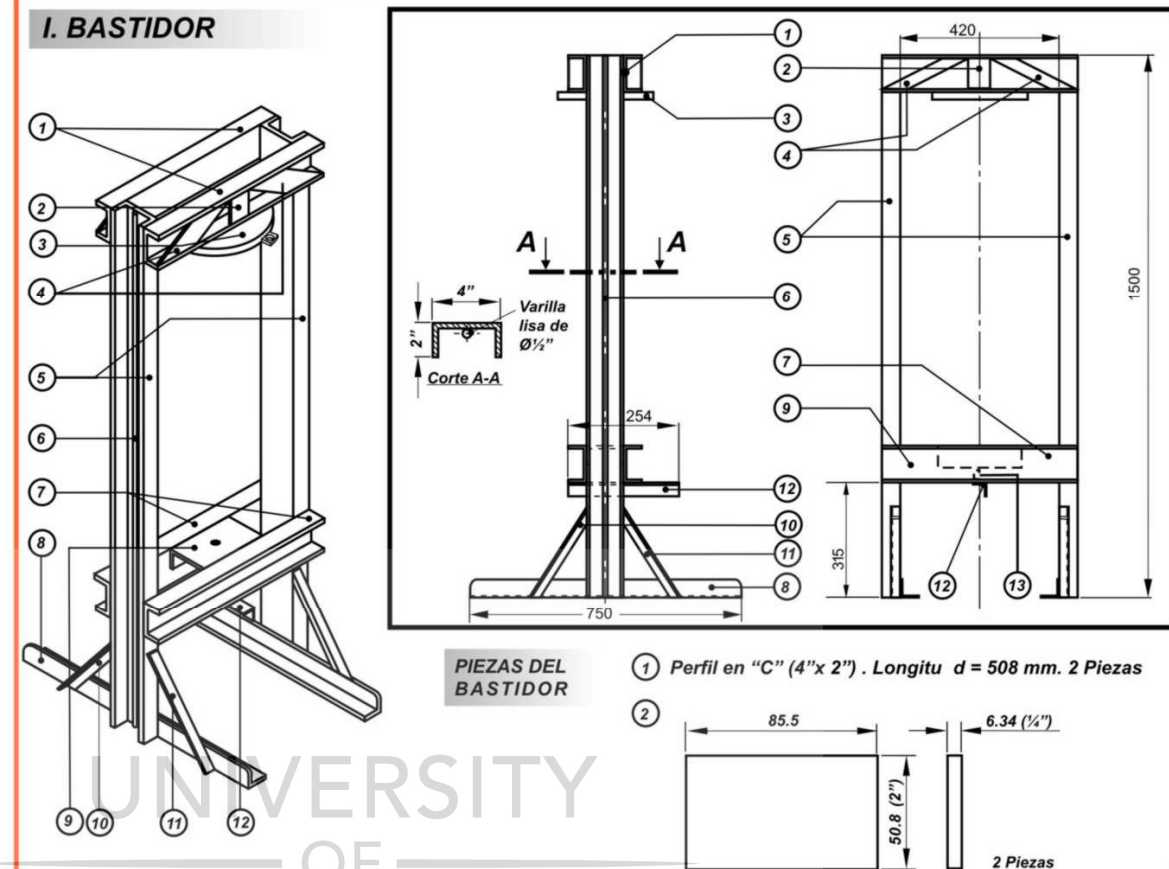
MANUAL INSTRUCTIVO PARA FABRICACION DE LA PRENSA PARA FABRICACION DE FILTROS

PARTES PRINCIPALES DE LA PRENSA PARA FABRICACION DE FILTROS



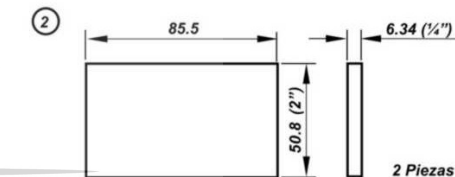
1.

I. BASTIDOR



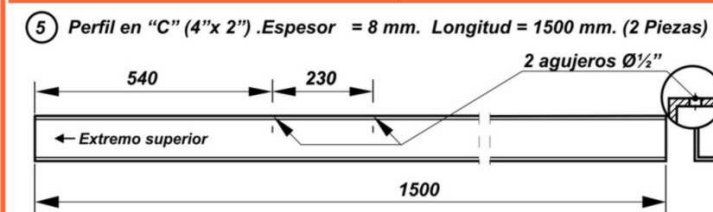
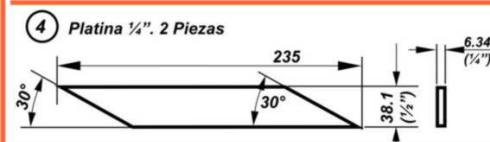
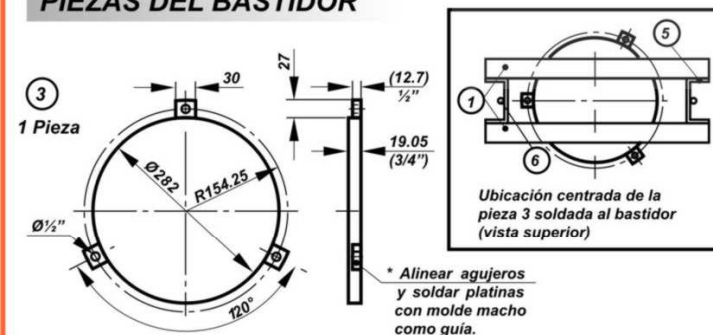
PIEZAS DEL BASTIDOR

1 Perfil en "C" (4"x 2"). Longitud = 508 mm. 2 Piezas



2.

PIEZAS DEL BASTIDOR



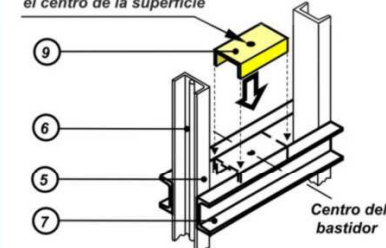
6 Varilla lisa $\varnothing 1/2"$
Longitud = 1500 mm. 2 Piezas

7 Perfil en "C" (4"x 2"). Espesor = 8 mm
Longitud = 508 mm. (2 Piezas)

8 Angular 2" x 2"
Espesor = 4 mm
Longitud = 750 mm
(2 piezas). * Redondear extremos.

9 Perfil en "C" (4"x 2").
Longitud = 180 mm. 1 Pieza

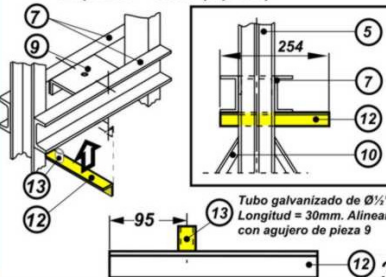
Perforar agujero de $\varnothing 1/2"$ en el centro de la superficie



10 11 Angular 1" x 1". Espesor 3 mm
* Cortar dos piezas derechas y dos izquierdas.



12 Angular 1 1/2" x 1 1/2". Long. = 254 mm
Espesor = 5 mm (1 pieza)

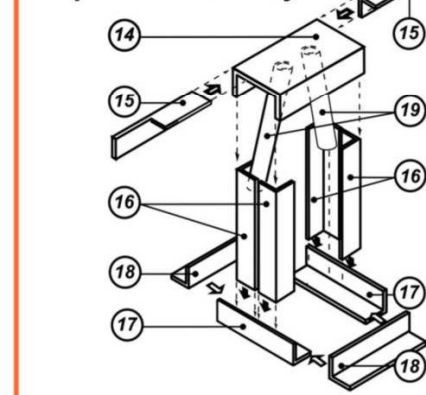


3.

II. SOPORTE DEL GATO HIDRAULICO

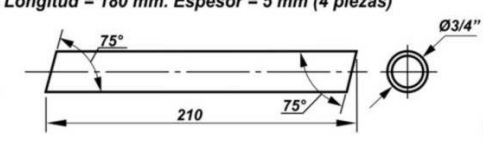


Esquema de montaje



Piezas del soporte del gato hidráulico

14 Perfil en "C" (4"x 2"). Longitud = 180 mm. (1 pieza)
15 Angular 1 1/2" x 1 1/2". Longitud = 164 mm. Espesor = 5 mm (2 piezas)
* Cortar una pieza derecha y otra izquierda.
16 Angular 1 1/2" x 1 1/2". Longitud = 197 mm. Espesor = 5 mm (4 piezas)
17 Angular 1 1/2" x 1 1/2". Longitud = 180 mm. Espesor = 5 mm (2 piezas)
18 Angular 1 1/2" x 1 1/2". Longitud = 180 mm. Espesor = 5 mm (4 piezas)
19 Tubo galvanizado de $\varnothing 3/4"$
Longitud = 210 mm. (2 piezas)



4.

III. PALANCA

The technical drawing illustrates the construction of a lever mechanism. It features a main perspective view and three detailed views:

- Detalle A:** Shows a close-up of the pivot point where the lever arm meets the frame, indicating a 45-degree angle.
- Detalle B:** Provides a side view of the lever arm's connection to the base plate, showing the alignment of the tubes and the base plate dimensions.
- Detalle C:** Offers another perspective of the lever arm's attachment to the base plate, highlighting the structural components.

The main drawing shows the lever arm (22) pivoted at one end (20) and connected to a base plate (27) via a linkage system (21, 23, 24, 25, 26, 28, 29, 30). Dimensions include overall lengths like 1340 mm for tube 20 and 465 mm for tube 21, as well as various segment lengths and diameters specified in both imperial and metric units.

Piezas de la palanca

- (20) Tubo galvanizado Ø1". Long.= 1340 mm (1 pieza)
- (21) Tubo galvanizado Ø½". Long.= 465 mm (2 piezas)
- (22) Tubo galvanizado Ø½". Long.= 450 mm (1 pieza)
- (23) Tubo galvanizado Ø1". Long.= 50 mm (1 pieza)
- (24) Angular ¾" x ¾". Long.= 40 mm (2 piezas)
- (25) Tubo galvanizado Ø¾" Long.= 100 mm (1 pieza)
- (26) Tubo galvanizado Ø1" Long.= 40 mm (3 piezas)
- (27) Tubo galvanizado Ø1" Long.= 50 mm (6 piezas)
- (28) Platina 58 x 25.4 mm x 3 mm (1 pieza)
- (29) Angular ¾" x ¾". Long.= 25.4 mm (1 pieza)
- (30) Tubo galvanizado Ø¾" Long.= 170 mm (2 piezas)

IV- V MOLDES

Technical drawing of mold assembly IV-V. The drawing includes three main components labeled 31, 32, and 33.

- Component 31:** A top flange with a diameter of $\varnothing 200$ and a central hole of $\varnothing 18$. It is shown in a cross-section view with a thickness of $1/16''$ and a total height of $0.26.9$.
- Component 32:** The main body of the mold, with an outer diameter of $\varnothing 368$ and an inner diameter of $\varnothing 210$. It has a height of 255 and a bottom diameter of $\varnothing 120$. It is shown in a cross-section view with a thickness of $1/16''$ and a total height of $0.26.9$.
- Component 33:** An intermediate flange with a diameter of $\varnothing 120$ and a height of 200 . It is shown in a cross-section view with a thickness of $1/16''$ and a total height of $0.26.9$.

The drawing also includes a top view of the assembly showing the dimensions of the flanges and the main body. The top view of component 31 shows a diameter of $\varnothing 200$ and a central hole of $\varnothing 18$. The top view of component 32 shows an outer diameter of $\varnothing 368$ and an inner diameter of $\varnothing 210$. The top view of component 33 shows a diameter of $\varnothing 120$.

VI- SOPORTE DEL MOLDE HEMBRA

Pieza soldada al soporte

39 1 pieza

$\varnothing 3/8"$

120°

24

pieza formada por 3 platinas de 8 mm.

34

35

36

37

522

420

4"

38

32°

Piezas del soporte del molde hembra

- 34** Platina de $\frac{1}{4}" \times 2"$ de ancho .Longitud = 101.6 mm. (2 piezas)
- 35** Angular $1\frac{1}{2}" \times 1\frac{1}{2}"$. Longitud = 350 mm. Espesor = 5 mm (4 piezas)
*Redondear extremos.
- 36** Platina de $1" \times 3$ mm de espesor. Longitud = 250 mm. (4 piezas)
- 37** Angular $1\frac{1}{2}" \times 1\frac{1}{2}"$. Longitud = 105 mm. Espesor = 5 mm (4 piezas)
- 38** Perfil en "C" ($4" \times 2"$). Longitud = 420 mm. Espesor = 8 mm (1 pieza)

VII- GATO HIDRAULICO

Detalle A

38

40

38

40

14

14

Soldar a la pieza 38

41

42

43

Detalle A
Proyección isométrica

41- Platina de $\frac{1}{2}$ " Diámetro: Ø95
42- Platina de 3mm de espesor x 20 de ancho por L= 198mm
43- Platina de 3mm de espesor x 20 de ancho por L= 150mm
* Rodea la cabeza del tornillo del gato hidráulico.

Annexure 22

Import costs per container from China.

Hi

Following details for you:

Insurance for once off shipments:

0.25 - 0.35% of the value of the goods (include 10% access in the value)

Import Duty payable on goods:

15% Import duty (tariff code : 392390.90)

Cost of shipment : Terms FOB (freight on board) from China to - DBN
then from Durban on rail to Johannesburg.
(ROE = RATE OF EXCHANGE)

Disbursements:

| | | |
|-------------------------------------|---|--------------------|
| Freight 20 ft \$ 1100 ROE R11.00 | = | R 12,100.00 |
| BAF 20 ft \$ 500 " " | | R 5,500.00 |
| CAF | | R 400.00 |
| Railage | | R 3,900.00 |
| Terminal Handling | | R 1,000.00 |
| Turn In | | R 1,600.00 |
| Cargo Dues | | R 2,000.00 |
| Line Release | | R 195.00 |
| Documentation | | R 350.00 |
| Cartage City Deep to address in Jhb | | R 1,200.00 |
| | | <u>R 28,245.00</u> |

Clearing Charge:

| | |
|--------------------------------------|-------------------|
| Documentation | R 415.00 |
| Agency 4.5% (based on disbursements) | R 1,271.00 |
| Communication costs | R 85.00 |
| | <u>R 1,771.00</u> |

TOTAL FOR THIS EXERCISE: R 30,016.00

GERDY BOLTON

TOP TRAILERS (PTY) LTD

299 Dekema Road

Wadeville, 1422

Johannesburg

SOUTH AFRICA

Tel : +27 11 255 3000

Fax : +27 11 827 5902

E-Mail: gerdy@toptrailers.co.za

Web: www.toptrailers.co.za

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Annexure 23
Costing calculations of filters. Improved, and Filtron filters.

Requested quotes from various companies.

| Injection Moulding | Company Details | Location | Item | Tooling cost | Tooling/ 100 000 units. | Unit Cost, for quantity of 100 000 | Complete set: 3 components |
|--------------------|---|----------|------------------|---|-------------------------|--|-------------------------------------|
| | Africa Plastics http://www.africaplastics.co.za/ | SA | | | | | |
| | | | Receptade | - | | - | |
| | | | Lid | R 280 000 excl VAT | | R 12.60 /PC (24 October 2008) | |
| | | | Stand | - | | - | |
| | DITA Products http://www.dita.co.za/index.htm | SA | | (R1 005 000.00 total) | R 10.05 | | (R 90.00 27 October 2008) |
| | | | Receptade | R 415 000.00 excl VAT | | | |
| | | | Lid | R 250 000.00 excl VAT | | | |
| | | | Stand | R 340 000.00 excl VAT | | | |
| | Cn-moulding (China) Co., Ltd. http://www.cnmoulding.com/ | China | | To Ship moulds to SA- R 811 200* USD 78 000. 24 October 2008 | R 6.30 | | (R72.80* USD 7.00 24 October 2008) |
| | | | | To Keep moulds in China- R629 200* USD 60 500. 24 October 2008 | | | |
| | | | Receptade | R 327 600* USD 31500 (24 October 2008) | | | |
| | | | Lid | R160 000* USD 12500 (24 October 2008) | | | |
| | | | Stand | R171 600* USD 16500 (24 October 2008) | | | |
| CNC Wire Bending | Company Details | | Hanging Handle | Qty. | | Unit Cost | |
| | Pure Steel Products (PTY) Ltd. http://www.puresteel.co.za/profile.html | SA | Stainless Steel | 10 000 upwards. | | R 9.85 /PC (22 October 2008) | |
| | J & P Wire Products inc. http://www.jpwire.com | US | Galv. Mild steel | | | R6.76* USD 0.65 /PC (24 October 2008) | |
| Spigot | Company Details | | | Qty. | | Unit Cost | |
| | Ningbo Jiaji Electrical Appliance Factory http://www.jiajihairedryer.com/plastic_tap01.htm | China | | Bulk numbers: 100 000 units | | R5.72* USD 0.55 /PC (27 October 2008) | |
| Filter Element | | | | | | | |
| | Resource Development International - Cambodia http://www.rdic.org/home.htm | Cambodia | | Per filter, excluding packaging and shipping. | | R33.80* USD 3.25 /PC (27 October 2008) | |

*Calculated at R10.40 to US\$, on 29 October 2008.

Updated cost of Filtron USD = R10.14

| Cost per filter. | | | |
|--|-----------|----------|-------------------------|
| | USD* | Rand | |
| Filtron Filter. | USD 13.30 | R 138.32 | * Cost before shipping. |
| Calculated according to costing sheet Annexure 4 | USD 19.60 | R 203.84 | * Cost at JHB |

*Calculated at R10.40 to US\$, on 29 October 2008.

Numbers of mouldings per conainer

| | Units per container. 20' | # of containers |
|-----------------------|--------------------------|-----------------|
| Receptacle | 2500 | 40 |
| Stand | 2800 | 35 |
| Lid | 11000 | 9 |
| Total # of containers | | 84 |

Total shipping cost for all containers (annexure 21) R30 000 x 84 containers = R2 520 000
Total shipping cost divided by 100 000 units= **R25.20 shipping cost per set.**

Breakdown of Improved Filter Costs.

Calculating number of containers needed for 100 000 units shipped from China.

| Improved Filter Costing | SA | Abroad* | SA, once tools are paid off. | Abroad, once tools are paid off. |
|---------------------------------------|-----------------|-----------------|------------------------------|----------------------------------|
| Plastic parts | | | | |
| Tooling cost per set | R 10.50 | R 6.30 | | |
| Cost per set | R 90.00 | R 72.80 | R 90.00 | R 72.80 |
| Transport cost China to JHB | - | R 25.20 | - | R 25.20 |
| | R 100.50 | R 104.30 | R 90.00 | R 98.00 |
| Wire handles | R 9.85 | R 6.76 | R 9.85 | R 6.76 |
| Transport cost to JHB~ | - | R 2.30 | - | R 2.30 |
| | R 9.85 | R 9.06 | R 9.85 | R 9.06 |
| Spigots | - | R 5.72 | - | R 5.72 |
| Transport cost to JHB~ | - | R 1.96 | - | R 1.96 |
| | R 7.68 | R 7.68 | R 7.68 | R 7.68 |
| Filters | - | R 33.80 | - | R 33.80 |
| Transport cost to JHB~ | | R 11.49 | | R 11.49 |
| | R 45.29 | R 45.29 | R 45.29 | R 45.29 |
| Total cost per complete filter | R 163.32 | R 166.33 | R 152.82 | R 160.03 |
| Including 40% Markup | R 228.65 | R 232.86 | R 213.94 | R 224.04 |

*Calculated at R10.40 to US\$, on 29 October 2008.

~a rough transport cost was calculated at 34%, to accurate shipping costing, annexure 21)