ISSN (Online): 2455-7838
SJIF Impact Factor (2017): 5.705

EPRA International Journal of

Research & Development

(IJRD)

Monthly Peer Reviewed & Indexed
International Online Journal

Volume: 3, Issue:10, October 2018

Published By :
EPRA Journals

SJIF Impact Factor: 5.705 Volume: 3 | Issue: 10 |October| 2018 ISSN: 2455-7838(Online)

EPRA International Journal of Research and Development (IJRD)

SMALL- SCALE WATER TREATMENT FOR POLYTECHNIC COMMUNITY

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ABSTRACT

The small-scale water treatment uses sand filter bed and external filter to purify the water. 4.0 kg of Moringa Oleifera powder was used as the co-agulant and to kill the germs. The granular activated carbon was used to remove dissolve chemicals, odors, and taste from the water. The small-scale treatment was found to purify 459 gallons in 24 hours. The filtered water was tested using the world health organization (W.H.O) guideline. The water sample 'A' before the treatment was found to contain: Mn, Fe, Mg, Pb, Cu, Zn Coliform (0.061, 1.351, 1.724, ND, ND, ND, Present) respectively. And the water sample 'B' after the treatment was found to contain Mn, Fe, Mg, Pb, Cu, Zn, Coliform (0.02, ND, ND, ND, ND, 1.047, Nill) respectively. The result of the test carried out was found to compare reasonable with the allowable standard value recommended by the world health organization.

KEYWORDS: *Moringa Oleifera, Co-agulant, Purify, Treatment, Odors*

1.0 INTRODUCTION

Water treatment involves the processes that alter the chemical composition or natural "behavior of water". Primary water available includes surface or ground water, municipal or public water. Private water supply usually consists of ground water pumped from wells or boreholes. Water treatment originally focused on improving the aesthetic qualities of drinking water. The methods involved in improving the taste and odor of drinking water were recorded as early as 4000B.C. Ancient Sankrit and Greek writings recommended water treatment methods such as filtering through charcoal, exposing to sunlight, boiling and straining. Visible cloudiness later termed turbidity was the driving force behind the earliest water treatment, as many sources of water contained particles that had an objectionable taste and appearance. To clarify water, the Egyptians reportedly used the chemical alum as early as 1500 B.C to cause suspended particles to settle out of water. During the 1700s, filtration was established as an effective means of removing particles from water, although the degree of clarity achieved was not measurable at that time. During the late nineteenth and early twentieth century's, concerns regarding drinking water quality continued to focus mostly on disease-causing microbes (pathogens) in public water supplies. Scientists discovered that turbidity was not only an aesthetic problem; particles in water such as faeces could harbor pathogens. The design of most drinking water treatment systems built during the early 1900s was driven by the need to reduce turbidity and removing microbial contaminants that were causing typhoid, dysentery and cholera epidemics [1].

While filtration was a fairly effective treatment method for reducing turbidity, it was disinfectants like chlorine that played the largest role in reducing the number of waterborne disease, outbreaks in the early 1900s. In 1908, chlorine was used for the first time as a primary disinfectant of drinking water in Jersey City, New Jersey. Since the passage of the original safe drinking water Act of 1974, the number of water systems applying some type of treatments has increased. Filtration and chlorination remain effective treatment techniques for protecting water supplies from harmful microbes [2].

In the design of water treatment plants, the provision of safe water is the prime goal and anything less is unacceptable. A properly designed plant is not a guarantee of safety. However skillful and plant operation and attention to the sanitary requirements of the source of supply and distribution system are equally important. Water treatment plants have demonstrated the ability to produce safe water under adverse conditions. Most of the outbreaks that have occurred in recent years have been caused by inadequate control of treatment facilities, contamination of untreated supplies, storage tanks and distribution systems. These serve as remainders of the need for uninterrupted treatment and unceasing attention to operating detail [3].

Ideally, appealing water is one that is clear and colorless, pleasant to taste and cool. It is non-straining and it is neither corrosive nor scale forming. Engineers, managers and operators are aware of the consumer's growing sensitivity to the quality of water served and the demand in many places for better water quality. Experts for supplies of excellent natural quality have the responsibility of producing appealing water which rests mainly with the treatment plant. In satisfying the demand for appealing water, the treatment plant must be able to cope with variations in flow and raw water quality to produce a water of uniformly good quality. An additional reason for the production of appealing water is to discourage the consumer from turning to some other unsafe sources of water. The consumer is principally interested in the quality of water delivered to the tap in his home or place of business, as opposed to the quality at the treatment plant. Therefore water utility operations should be such that quality is not impaired as water flows from the treatment plant through the distribution system to the consumer [4].

The untreated drinking water contains some dissolved substances and some toxic contaminants which makes the water harmful to the body. Pathogens are contained in untreated water which causes diseases like Cholera, Gastro-enteritis, Hepatitis, Typhoid fever etc. Hardness in water both the temporary and permanent hardness are found in an untreated water. Washing becomes costly because hard water wastes soap because it forms scum with soap. It also waste fuel while boiling water in kettle causing inefficiency. The water treatment was able to eliminate the difficulties that untreated water has been causing to people.

2.0 LITERATURE REVIEW

A review was made of the water treatment developed by many researchers for household use and found to be different from the one we produced.

2.1 Bucket Filters

Bucket filter systems of granular media for household use usually require two or three buckets, one of which has a perforated bottom to serve as the filter vessel. The bucket with the perforated bottom is filled with a layer of sand, layers of both sand and gravel, or other media. Gravel and sand media of specified sizes often can be purchased locally. Alternatively, these media can be prepared locally by passing sand and gravel through metal sieves of decreasing mesh size and retaining the material in the appropriate size ranges (between 0.1 and 1 mm for sand and about 1-10 mm for gravel). Sand or other local granular media are placed in plastic or metal buckets approximately 2.5-gallon (10-liter) to 10-gallon (40-liter) capacity and having bottoms with perforations to allow water to drain out. The media of bucket filters must be cleaned or replaced on a regular basis to remove accumulated particles and to prevent the development of excessive microbial growths that will degrade water quality [5].

The major drawback of this bucker filters is the frequency of filter media replacement and cleaning (maintenance) add more running cost to the water treatment.

2.2 Drum or Barrel Filters

A number of different designs for drum or barrel filter having either up-flow or down-flow of water has been described for use as rapid granular medium filters. These filters are usually 55-gallon (about 200-liter) capacity steel drums and contains sand and gravel media similar to that used for bucket filters [6]. The filters generally have a cover to prevent the introduction of airborne and other contaminants. Down-flow filters have a perforated pipe at the bottom to collect the water passing through the medium and discharge it from the side of the drum. The outlet pipe for filtered water may discharge the water at the bottom of the drum or it may be configured with an upward bend or loop to discharge the water at the same level as the top of the media in the filter. The major drawback of this drummer barrel filter is that no provision was made for destroying the viruses and pathogens in the treatment. Some impurities that are small in size may also pass through the filter.

2.3 Roughing Filters

Simple, low cost, low-maintenance, multi-stage roughing filters for household and community use have been described and characterized [7, 8, 9]. Typically, these filters are rectangular, multi-compartment basins constructed of concrete or other materials. They require modest skills for operation and maintenance, and best suited for use by communities or at least multiple households. However, it is possible for these multi-compartment tanks to be centrally fabricated and distributed at low cost for placement and final installation at their locations of use. Many of these filters are designed to use two different sizes of low cost, coarse granular media in two or three compartments or stages and such media are generally locally available. The filter has provision for backwashing (at the bottom of the filter medium chamber in the horizontal and down flow filter designs). Roughing filters usually consist of different size of filter materials decreasing successively in size in the direction of flow. Most of the solids are separated by the coarse filter medium near the filter inlet with additional removal by the subsequent medium and fine granular media in subsequent compartments [10].

The major drawback of the roughing filters is it requires modest skills for operation and maintenance, and the removal of bacterial by roughing filters cannot be guaranteed since no report was given on it.

2.4 Filter-Cisterns

Filter-cisterns have been in use since ancient times in areas heavily supplied with rainwater or other water sources but lacking land area for reservoir or basin storage. In this filtration system cisterns or large diameter well casings partially below grade are surrounded by sand filters such that water flows through the sand and into the casing or cistern either from the bottom or through the side of the casing near the bottom, such filter-cisterns function as infiltration basins to remove turbidity and other particulates. Today, filter cisterns are being used in Sri Lanka to treat and store rainwater from roof catchment systems [11].

The major draw backs of this filter- cisterns treatment plant is the filter cisterns is a very large treatment plant that cannot be used in houses. The plant is expensive because of its size.

2.5 Biomass and Fossil Fuel Granular Media Filters

Historically, depth filters composed of filter media derived from vegetable and animal matter have been employed for water treatment. Coal-based and charcoal filter media have been used since ancient times and carbon filter media are widely used today for both point-of-use and community water filtration systems [12]. Filters containing sponges were widely used for on-site or point-of-use household and military water treatment in 18th century. Other medium that also employed the use of this filters included sand, cotton, wool, linen, charcoal and pulverized glass, either individually or in various combinations as successive layers.

The major drawback of the biomass and fossil granular media filters is the sponge filters that imparted objectionable tastes and odor to the water unless they are cleaned regularly, this is an indication that microbial growth and biofilms probably were a major problem with these filters.

3.0 COMPONENT OF THE WATER TREATMENT

3.1 Sedimentation Tank

This is a tank where the initial muddy or raw water is stored. It is in this tank that the initial application of Moringa Oleifera takes place in other to kill the bacteria and other micro-organisms. The tank was constructed with a stainless steel which is resistance to corrosion.

3.2 Combine Cylinder

The combine cylinder is constructed with stainless steel. It has dual purpose of housing industrial sand and activated carbon. The combine cylinders has two main chambers referred to as upper and lower chambers, one on the top of the other. The upper chamber is designed to accommodate 35kg of fine sand, 30kg of coarse sand and 35kg of pebbles. It has a lid which is conical in shape; it is through this opening that the sand stone is feed into the system. A fiber gasket is used for proper sealing of the lid to stop leakages. The upper chamber has three openings or ports, two on the body (600mm apart), for inlet and outlet of water respectively and the third one is on the cone for the purpose of backwashing.

The lower chamber is joined to the upper such that there is no leakage from the upper to the lower chamber except through the outlet port provided at the lower point of the upper chamber. This second chamber is constructed to house granular activated carbon and it also has three ports, two at the top (152mm apart) and bottom side for inlet and outlet of water into and out of the chamber respectively. The third chamber is at the bottom of the cone for flushing the system during quality control process. It houses 20kg of activated carbon and can be fed into or removed from the chamber through an opening provided at the side of the chamber.

3.3 Treated Water Tank

This tank is similar to the sedimentation tank and has the same dimensions and shape with the sedimentation tank. The difference between the treated tank and the sedimentation water tank is the provision of tap head for collection of drinking water on the treated water tank and also the stand on the sedimentation tank. The sedimentation tank is higher than that of the treated water tank because of the difference in height. The difference in height enables the flow of water through the system.

3.4 Water Line

The PVC pipes are used for connecting the system. The PVC pipes are resistance to corrosion and free from lead poisoning.

3.5 Water Source

The source of water used for the analysis is the borehole water used by the Federal Polytechnic Mubi community (sample A).

3.6 Reusable Filter

The water from the combine cylinder flows through the reusable filter to remove the escaped particles especially from the activated carbon

3.0 METHODOLOGY

Method: Colorimetric, Organoleptic, AAS, Air Acetylene Flame integrated mode, Buck 210 Model, Filtration was used for the analysis.

4.0 MATERIAL SELECTION

4.1 Stainless Steel

Stainless Steel Sheet is used for the housing for the Treatment Plant due to its Superior resistance to rust and better aesthetics value,

4.2 Cast iron

The Stand for the Treatment Plant was constructed from this material because it is strong, durable and is able to withstand both rough handling and load.

4.3 PVC Pipes:

This plastic material was used because it has no lead poisoning and does not corrode.

4.4 Sand Stone and Pebbles

Sand stone and pebbles are selected because they are cheap, inert, durable, and readily available. It has been extensively tested and found to give excellent results.

4.5 Granular Activated Carbon (G.A.C)

For drinking purposes water should not contain any taste or odor. The odor of water can be measured in terms of threshold odor number between one (1) and three (3). Carbon granules strongly attract organic chemicals removing them from the water by a process called adsorption. The absence of dissolved chemicals like H_2S, CH_4, CO_2, O_2 etc and some mineral substances like Iron, Sulphate will produce odorless water.

4.6 Volume of Moringa Oleifera Powder needed

Moringa Oleifera seed powder was used to kill the germs in the water. The volume that was used is between 3.5 mg - 10mg per litre of water.

4.7 Working Principles of the Small-Scale Water Treatment

The process starts from the overhead sedimentation tank where the raw water was treated with Moringa Oleifera powder of between 3.5mg and 10mg per litre of water depending on the muddiness of the water. It is then left for 15 minutes to react by stirring for five minutes before use. The ball gauge at the orifice is released and water flows into the combine chamber with high pressure. The combine chamber comprises of the upper and lower chamber one on top of the other. At the upper chamber, water flows through the pebbles, through the coarse sand of size between 0.6mm-1.0mm and finally through the fine sand of size between 0.35-0.60mm. The water is then channeled through the line to the lower chamber. The lower chamber is made to house the granular activated carbon (G.A.C) whose function is to absorb odors and dissolved chemicals from the water including those released by the Moringa Oleifera powder. The powder was used to treat muddiness from water, and other source. The water is then channeled to a reusable polyester filter of 1 micron where any escaped particles from the combine chamber is trapped to produce pure water free from contaminations and collected at the treated water tank for the purpose of consumption.

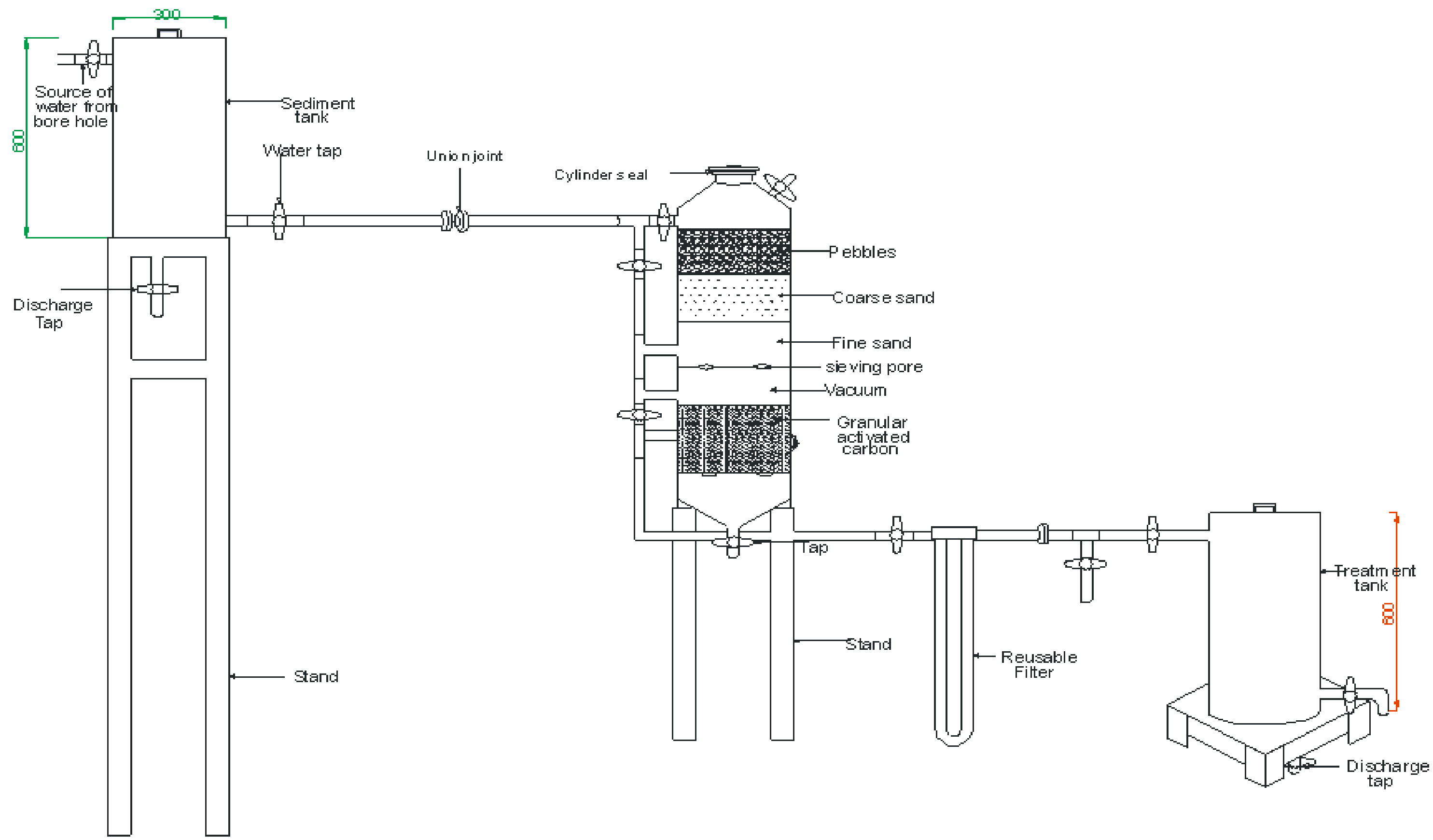

Fig. 1 A Section of the Small -Scale Water Treatment

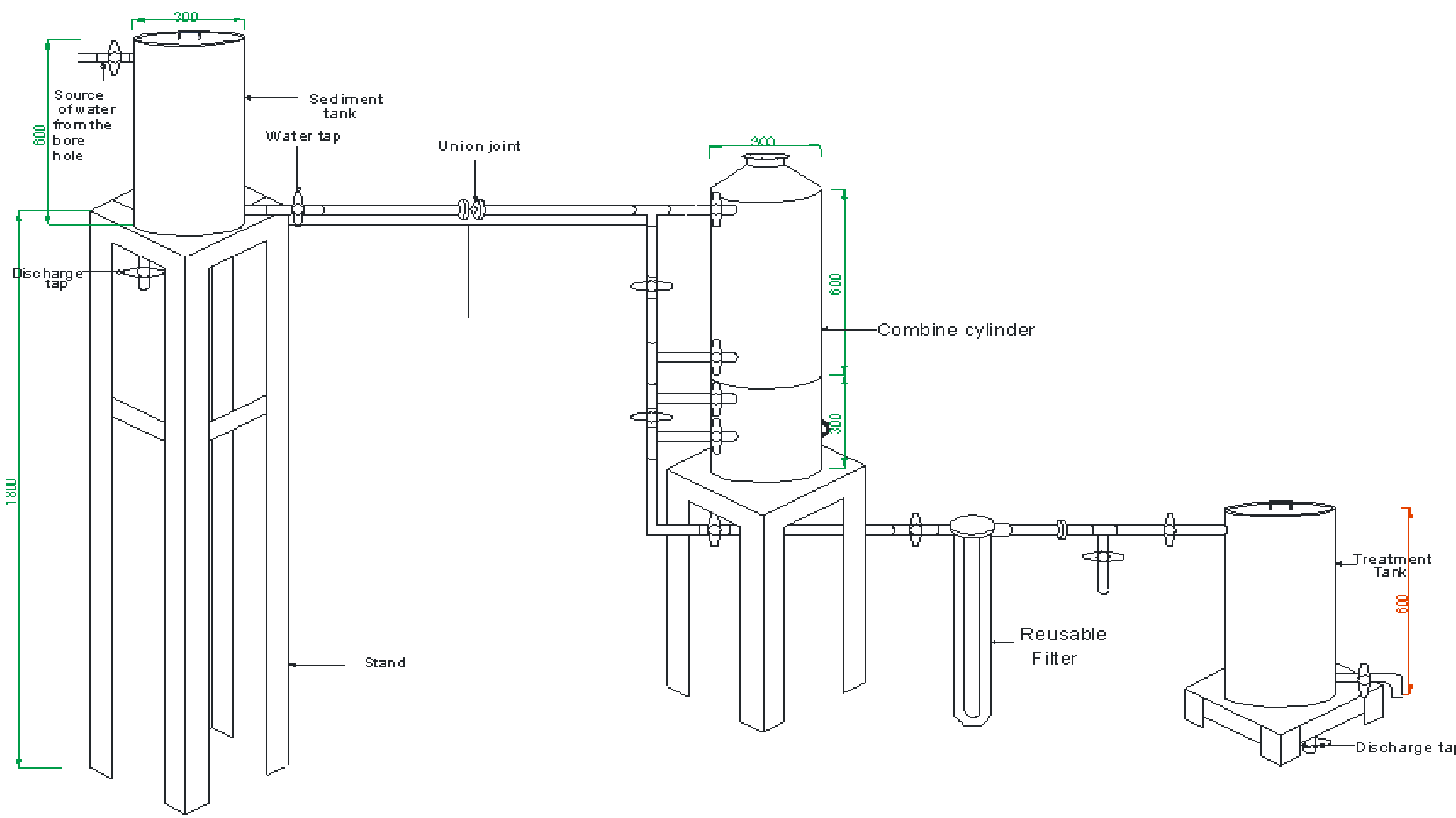

Fig. 2 Assembly of the Small-Scale Water Treatment

5.0 RESULTS ANALYSIS AND DISCUSSION

5.1 Results of Water before the Treatment (SAMPLE A)

From the test result of the untreated water (Sample A) shows that both Manganese(0.061Mg/L) and Magnesium(1.724Mg/L) exceeds the safe limits as shown in Table 1 (W.H.O Drinking water standard). Manganese and magnesium are of serious health risk since excess of any of them can cause Neurological disorder. The value of iron found in the drinking water was 1.351. Pb, Cu, Zn were not detected in the untreated water. Also, the indication in the bacteriological examination shows that using the probability table to estimate the most probable number of Coliform Bacterial, the count is estimated at 4/100ml of water. From table 1, the water sample can be classified as intermediate.

Table 1: Sample 'A' Water from Polytechnic Bore-hole before Treatment

Type of Test	Element	Unit	Test Remarks	Method
Physical	Colour	Pt. Co scale	3	Colorimetric
	Odour	Pt. Co scale	Negative	Organoleptic
	Taste	Pt. Co scale	Normal	Organoleptic
Chemical	Mn	Mg/L	0.061	AAS
	Fe	Mg/L	1.351	AAS
	Mg	Mg/L	1.724	AAS
	Pb	Mg/L	ND	AAS
	Cu	Mg/L	ND	AAS
	Zn	Mg/L	ND	AAS
Bacteriological	Coliform	Per 100ml	Present	Filtration

ND = Not detected or beyond detection limit **N/A** = Not Applicable

Appearance: Grayish white and clear

Most probable number of tubes showing positive result

50ml 0 10ml 2 1ml 2

Sample B

From the test result of the treated water (Sample B), it shows that both Manganese and Magnesium were now reduced after passing through the water treatment system by 67% and 100% with values (0.02Mg/L and ND) respectively, which are below the safe limits given in Table 3 (W.H.O Drinking Water Standard). Although, Zn which was originally absent in the raw water was now detected in the treated water with value (1.047). The value did not exceed the safe limit given in Table 3 therefore; the value has no health effect on consumers. Iron which was present in the untreated water was not detected. Pb and Cu which were not seen in the untreated water were not detected after passing through the water treatment. Also, the indication in the bacteriological examination shows that using the probability table to estimate the most probable number of coliform bacterial, the count is estimated at 1/100ml of water. From table 2 below the water sample 'B' can be classified as Satisfactory

Table 2 Sample 'B' Water Analysis Report (The Treated Water)

Type of Test	Element	Unit	Test Remarks	Method
Physical	Colour	Pt. Co scale	13	Colorimetric
	Odour	Pt. Co scale	Odourless	Organoleptic
	Taste	Pt. Co scale	Tasteless	Organoleptic
Chemical	Mn	Mg/L	0.02	AAS
	Fe	Mg/L	ND	AAS
	Mg	Mg/L	ND	AAS
	Pb	Mg/L	ND	AAS
	Cu	Mg/L	ND	AAS
	Zn	Mg/L	1.047	AAS
Bacteriological	Coliform	Per 100ml	Nill	Filtration

Appearance: clear and colorless
Most probable number of tube showing positive result

50ml 1 10ml 0 1ml 0

Table 3 World Health Organization (W.H.O) Drinking Water Standard

Type of Test	Element	Unit	Requirement	Method
Physical	Colour	Pt. Co scale	15	Colorimetric
	Odour	Pt. Co scale	Odourless	Organoleptic
	Taste	Pt. Co scale	Tasteless	Organoleptic
Chemical	Mn	Mg/L	0.03	AAS
	Fe	Mg/L	N/A	AAS
	Mg	Mg/L	0.20	AAS
	Pb	Mg/L	0.01	AAS
	Cu	Mg/L	0.05	AAS
	Zn	Mg/L	3	AAS
Bacteriological	Coliform	Per 100ml	Nill	Filtration

6.0 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

A small-scale house hold water treatment was developed having three units, viz; sedimentation tank, combine cylinder and treated water tank. The volumetric capacity of both the sedimentation and the water treated tank is 45 litres. And the volume of Moringa used as disinfectant and coagulant was 4.0 mg per litre of water. The plant was tested for is product and found to compare reasonable with the standard values provided by world health organization.

6.2 Recommendations

1. This kind of treatment facility should be introduced to rural areas, since it is cost effective and easy to operate.
2. A provision for backwash should be made separately for the upper and lower chambers
3. An electric pumping machine should be provided since during backwashing more pressure is required.

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