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Laboratory Studies of Raw Water Treatment using Plaster of Paris (Pop) and Block (Sandcrete) as Filter Media

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Abstract

Raw water is characteristic water found in our environment that has not been treated or purified, nor minerals, ions, particles, or living organisms been expelled. Polluted water leads to death in several countries, including Nigeria, as water the major need of every living thing is in crisis. Different innovations and techniques have been used in treating water; however, these techniques are very expensive. This has led to more research using low-cost materials to construct a filter for convenient drinking water purification. The method used in this research was filtration through adsorption in the treatment of raw water, using commercial plaster of Paris and block as a filter for raw water to pass through. The filtrates were then processed for the viable Coliform count, dissolved solids, Turbidity, pH, Temperature, and suspended solids. The filtration unit attained 98% TDS removal, 57% TSS removal, 86% Turbidity removal, 49% Temperature increase, 26% increase in pH, 91.8% of E-Coli removal and 99% of bacteria removal. The results obtained were in accordance with EPA and WHO standards and are recommended for urban reuse.

Keywords - *Plaster of Paris (POP), Block (Sandcrete), Effluent, Raw Water, Filtration.*

I. INTRODUCTION

The significance of water to humans and other biological bodies cannot be overemphasized. There are various economic factors that any shortage or pollution can cause severe death to living species. As water production and water consumption increase, the shortage of water has grown over the years among humans and the requirement for reuse of water. These concepts for reusing water have been widely embraced by developing and developed countries as they experience a shortage of water utilized [1]. Water pollution issues are traced back to the eighteen century with the outbreak of cholera and other water-borne diseases in Europe and Asia. Over a billion people on the planet have no access to safe drinking water, they rely upon water from lakes, streams, and open wells, which are dangerous for usage, and many developing nations (urban areas, poor rural territories, and indigenous groups) experience the ill effects of these water [2],[3].
For centuries the essential focus of treating water was to make it potable and safe for people. As a result of these discharges, there have been different innovative strategies; for example, reverse osmosis, electrochemical coagulation, Nanofiltration, and adsorption used to treat wastewater. Among these strategies; is the adsorption (mainly through filtration) procedure, which has increased impressive enthusiasm for recent times because of the high state of treatment and level of reliability, which can meet stringent environmental emission standards. The adsorption technique is accounted for to be feasible and economically reasonable for the treatment of effluent from industrial procedures [7], [8].

Adsorption has proven to be sustainable development projects and industrial boom in various sectors, which has impacted the existence of humans and the current trend of our economy. With great values such as; reduction on wastewater disposal into the ocean, streams and lakes have been made clean including the ocean and save for aquatic lives and the utilization of by-products and waste materials as a raw material since they are in abundant, renewable and cheap for water treatment to reduce the cost of treatment [7], [9], [8].

Filtration is defined as the effluent capacity to flow down the filter without a pump's guide, and the filter is said to be gravity[1]. Filtration is utilized to isolate non-settleable solids from water and wastewater by passing them through a permeable medium. The most widely recognized framework is filtration through a layered bed of granular media of course or finer sand [1], [10]. Filter medium-capacity functions in a few ways to give clear filters [11], [10]. Reference [10] noted that slow sand filtration has been perceived as a filtering innovation for drinking water treatment in provincial zones and is perceived as a reasonable filtration innovation for removing water-borne pathogens and diminishing Turbidity. It is equipped for enhancing the physical, chemical, and microbiological nature of water in a solitary treatment prepared without the expansion of chemicals and can create effluent low in Turbidity and free of microscopic organisms, parasites, and infections [11]. Reference [9]demonstrated that sand filters at a depth of 150cm could evacuate Faecal Coliform and suspended solids from Stream water for three days. Reference[12]investigated the Plaster of Paris ($CaSO_4.\frac{1}{2}H_2O$) at the optimum dose was 1g/50 ml of fluoride solution to remove fluoride from synthetic water. They observed that at neutral pH, 83.5% of fluoride saturation was achieved within 20 minutes. The adsorption reaction was spontaneous and exothermic. Reference [13]built seven diverse minimal effort channels inside 50ml plastic syringes, and three channels were made with mortar of pop. Simultaneously, the remaining four were a mixture made with mortar of pop, marble powder, and sand. These channels were utilized to expel microorganisms from diluted sewage water. They also observed that the productivity of filter with pop alone did better and removed all coliforms.

This study aimed to treat raw water using the Plaster of Paris (pop) and block as filter media. The specific aim was to assess these media's use and application to provide potable water by removing the nutrient contaminants. However, the main objective was to evaluate the block's adsorption capacity (Sandcrete) and pop on raw water using filtration to remove undesirable contaminants like pathogens, Turbidity, pH, Temperature, hardness, and suspended solids to achieve safe water or its reuse to meet drinking water standards.

II. MATERIALS AND METHOD

A. Materials

The materials used for this study was Plaster of Paris (pop) and Blocks (Sandcrete). The pop and block were obtained from the building material market in Nsukka, Enugu State; the stream water was collected from Trans-Ekulu Avenue, Abaka River at Latitude 6.46973 and Longitude 7.49704 Enugu, Enugu State, South-Eastern Nigeria.

B. Manufacturing the Filter System

The filter was connected to allow water to drip out through the pipes. The system had a water supply tank filled with river water and connected to the filtration system through pipes. It was designed to supply the river water to the filter and flowed out into a plastic container of 2 liters with a tap attached to it for effluents to flow out into a bicker. In the container were pop (10cm) and block (40cm) inserted, and the time interval for measuring the volume of water was 24 hour

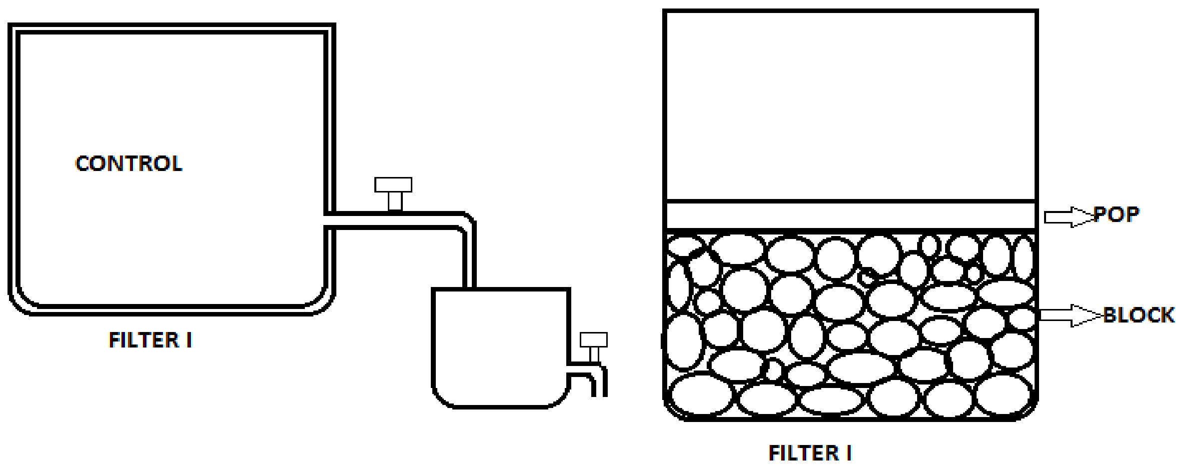

Fig 2.1: Schematic View of Filter

C. Preparation

The container was washed with distilled water and air-dried. A white transparent material was placed directly under the pop with the container labeled Filter I.

D. Methods (Test Experiments)

Standard methods established for removing Total Solids, Total Suspended Solids (TSS), Total Dissolved Solids or Filterable Solids (TDS), Temperature, Turbidity, and Coliform Count from the water was used.

III. RESULTS AND DISCUSSION

As the effluent flows through the porous block and pop along with a tortuous route, the particulates come close and are removed by adsorption. On the contrary, the filter was more effective in the removal of TSS in the effluent samples. Some of the interesting physical characteristics that promote the removal of suspended and dissolved solids are the high surface area, small porosity (that allows the trapping of solids during transportation), and poor water retention ability. These results are represented graphically as presented in Figures 3.1, 3.2, 3.3, 3.4 &3.5, and the physical/biological parameters of the raw water before treatment are represented in the table below.

Table 1: physical and biological parameters of raw water

Parameters	TSS	TDS	Turbidity	pH	Temperature	E. Coli	Coliform Bacteria
Results	75 mg/L	15 mg/L	19 NTU	4.5	24 ºC	1800 CFU/100 ml	1800 CFU/100 ml

A. Performance of filters concerning physical parameters

1. TOTAL SUSPENDED SOLIDS (TSS)

As the effluent flows through the porous pop and block along a tortuous route, the particulates come close and are removed by adsorption. Some of the interesting physical characteristics that promote the removal of suspended and dissolved solids are the high surface area, small porosity (that allow the trapping of solids during transportation), poor water retention ability as values obtained fell under Nigerian Industrial Standard [14], Environmental Protection Agency [15] and World Health Organisation [16]standard.

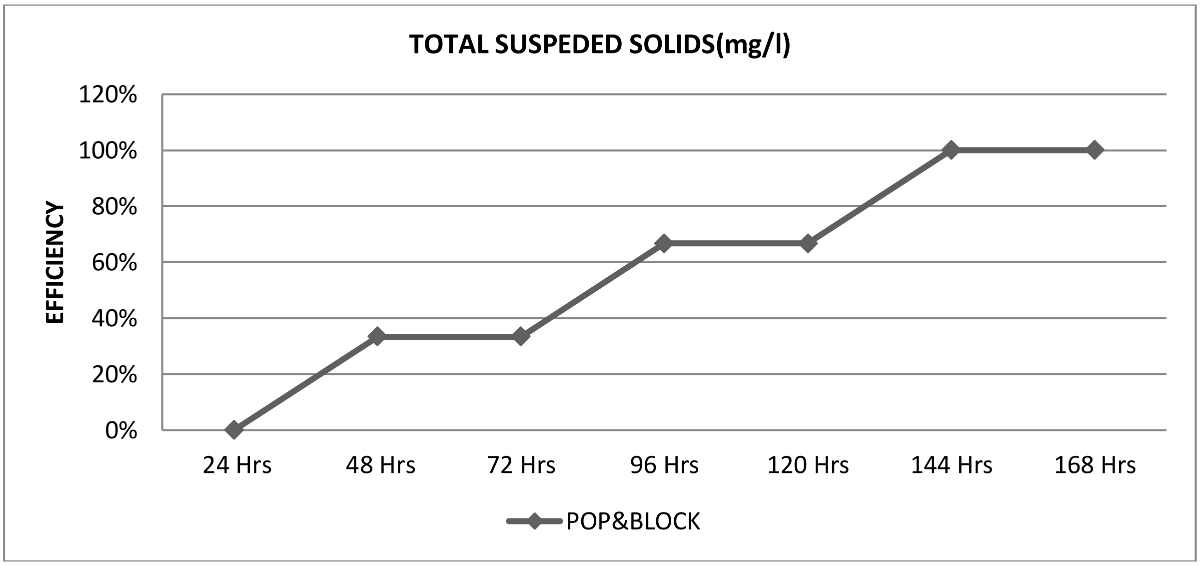

Figure 3.1: Comparison of the efficiency of TSS and time

Figure 3.1 shows the percentage of removal of TSS in raw water after treatment. The amount of TSS recorded (Control) is 1.5mg/L. It was observed that; the concentration of TSS did not reduce from its initial value of 1.5mg/L after 24hr with an efficiency of treatment estimated at 0%. At 48hrs to 72hrs, it had a steady efficiency of treatment estimated at 33%, then increased and became steady to 67% at 96hrs to 120hrs. There was no trace of TSS after 144hrs.

2. TOTAL DISSOLVED SOLIDS (TDS)

It was observed in Fig. 3.2 that as the time increased, the filter became more effective, thereby increasing the treatment efficiency of effluent from the filters as values obtained fell under Nigerian Industrial Standard[14], Environmental Protection Agency [15]and World Health Organisation [16] standard.

The concentration of TDS, as shown in figure 3.2, reduced from its initial value of 75mg/L to 13.5mg/L after 24hr with an efficiency of treatment estimated at 95%.

At 120hrs, there was no TDS trace as it reduced to 0mg/L at an efficiency of 99.9% till 168hrs. At 72hrs, TDS was reduced to 0.5mg/L at an efficiency of 99.3% and became steady to 96hrs, then reduced to 0mg/L at 120hr with an efficiency of almost 100% till 168hrs. However, it was observed that as time increased, the treatment efficiency of effluent from the filters also increased.

3. TURBIDITY

For Turbidity, Fig. 3.3 showed the filter did better due to the combination of both pops and block with efficiency from 19 NTUto 6 NTU (81% to 90%). The turbidity removal at 24hrs was 80% and improved gradually at 48hrs with a steady increment from 96hrs to 168hrs as the efficiency remained stable at 90%.

4. PH

According to the WHO[16], the pH values recommended for drinking water is 5 – 8.5. However, pop and block increased the pH above 8 in the first 48hrs, as shown in Fig 3.4.

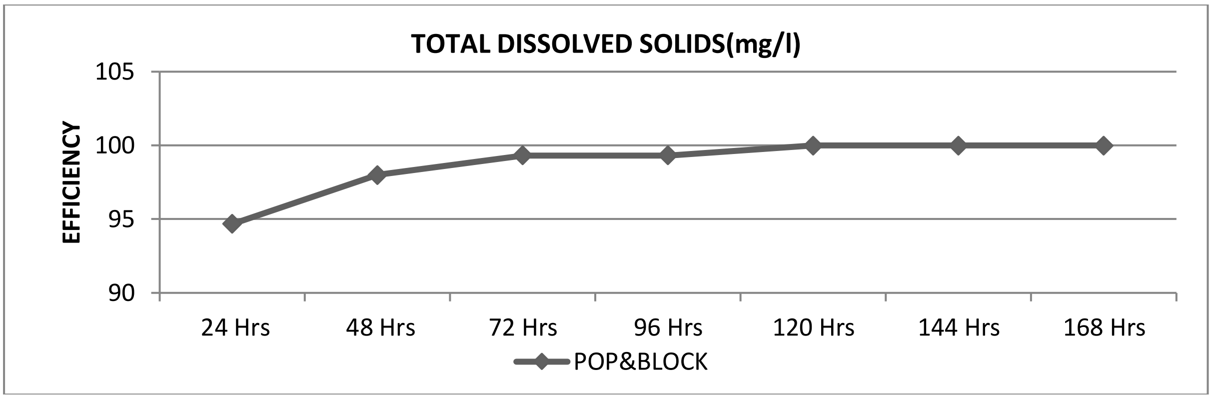

Figure 3.2: Comparison of the efficiency of TDS and time

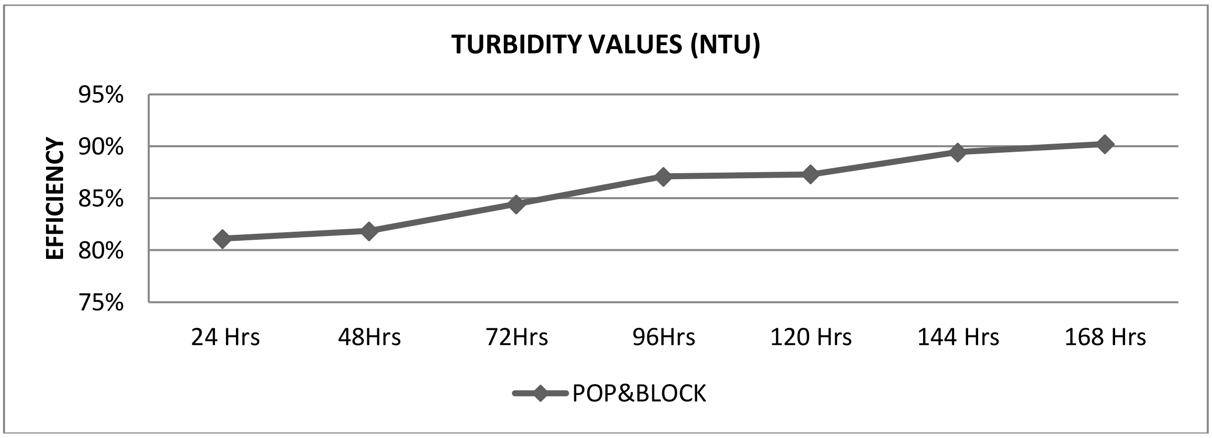

Figure 3.3: Comparison of the efficiency of Turbidity and time.

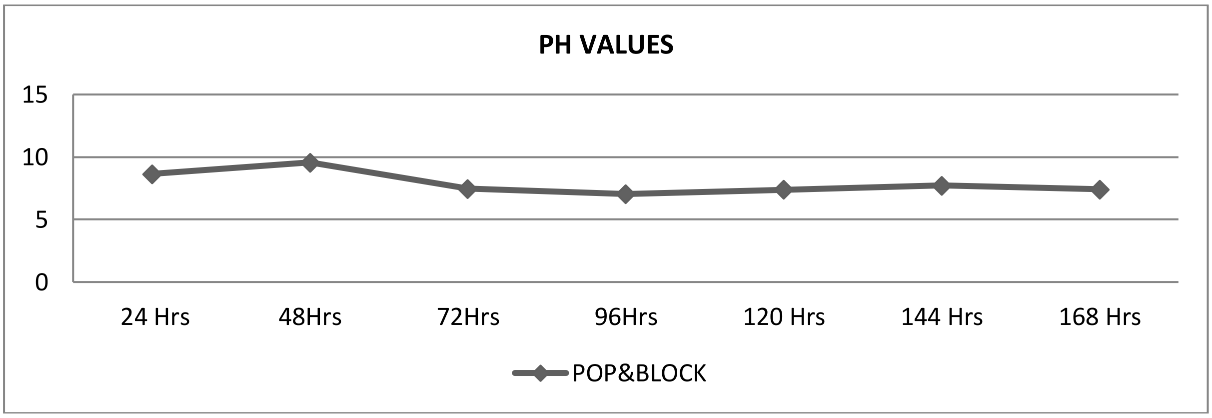

Figure 3.4: Comparison of pH and time

The PH of the influent and effluent raw water from the treatment system was relatively unsteady, with an observed average of 7.6. The acidity in the water was reduced to neutral with time. The increase in pH may be due to the presence of negative charges on the pop's surface and in accordance with [17, 18]. The filter units were effective in pH removal as the values reduced to neutral after 168hrs.

5. Temperature

Figure 3.4 it was observed that the pH value increased from acidity of 4.49 (control) to alkalinity of 8.7 at 24hrs, which increased slightly again at 48hrs, then dropped to neutral and became stable till 168hrs.

The filter units were effective in pH. The PH of the influent and effluent raw water from the treatment system was relatively unsteady, with an observed average of 7.9. The acidity in the water was reduced to neutral with time. The Temperature of the treated effluent as seen in Figure 3.5 was relatively unsteady with an observed average of 28.6ºC and an efficiency of 49%, as a mark for an increase in the Temperature.

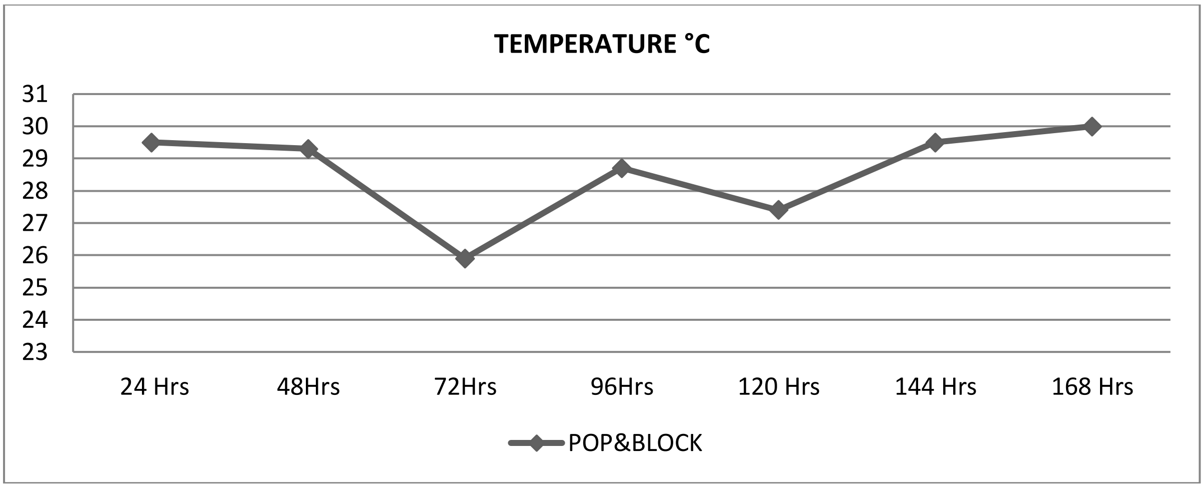

Figure 3.5: Comparison of Temperature and time

B. Performance of filter with respect to microbial parameter

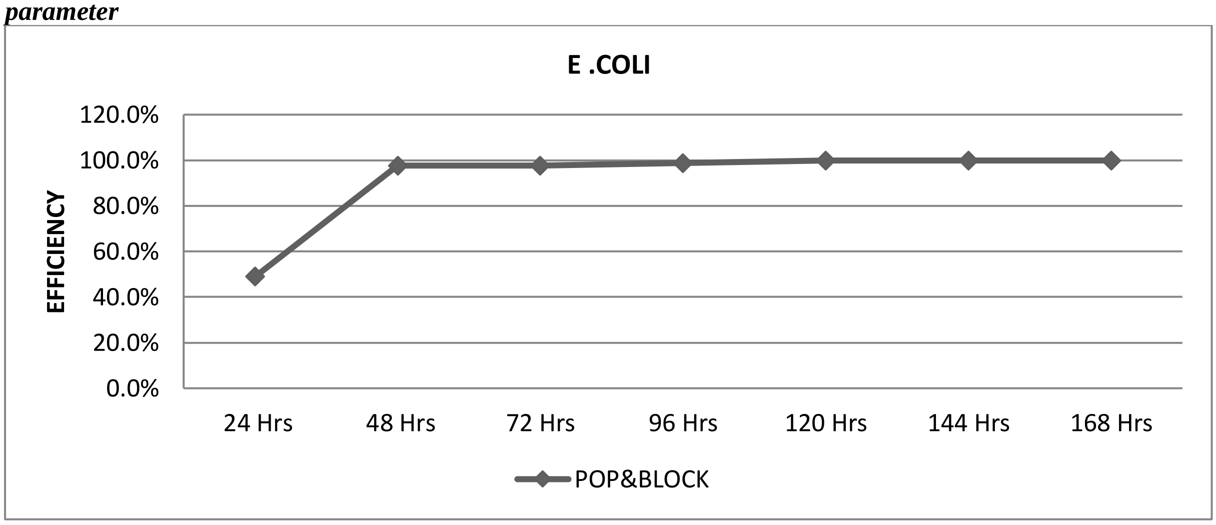

Figure 3.6: Comparison of the efficiency of E.Coli and time

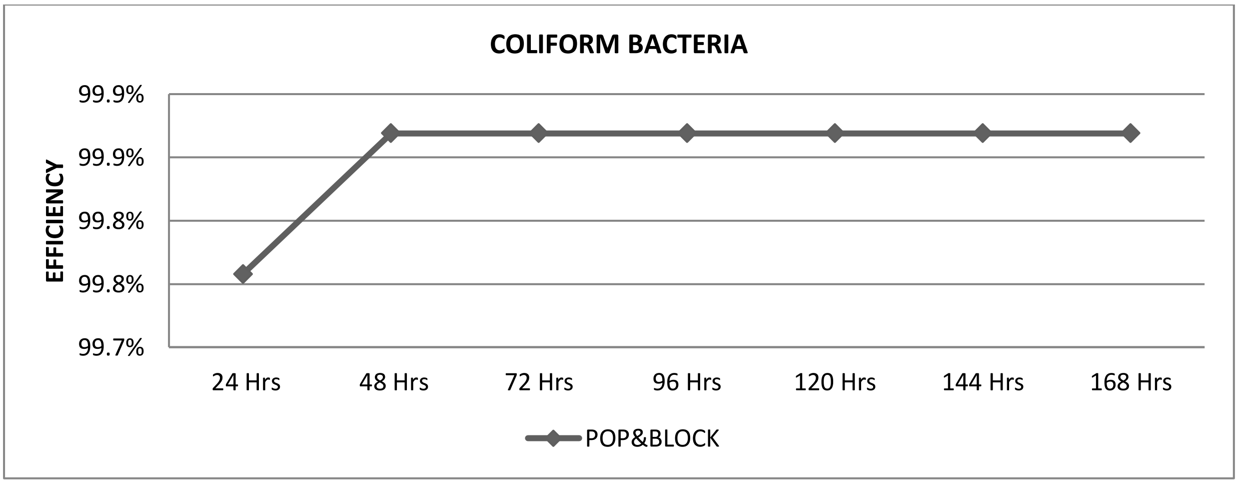

Figure 3.7: Comparison of the efficiency of Coliform Bacteria and time

The result obtained from the graph for total Coliform shows that during filtration, all the disease-causing bacteria and microorganisms were reduced to a minimum as they all fell below the control (>1800 CFU/100ml). The result obtained from figure 3.6 showed that E.coli (faecal Coliform) was completely reduced from the effluent as a combination of both Pop and block removed traces of colony-forming unit with a removal efficiency of 99%. The values obtained fell under WHO, EPA, and NIS [16], [15,

[14]standard after 120hrs (95% removal) of filtration. Figure 3.7 showed that the filter was able to trap some bacteria, causing diseases and microorganisms. However, it showed little or no colony-forming unit for the filtered water as they significantly did better with an efficiency ranging from 98% for 24hrs to 99% at 96hrs and 99.9% at 168hrs. The filter was able to trap some bacteria, causing diseases and microorganisms (both total and Faecal coliform) and agreed with [13], [19], [20]&[21].

It is very pertinent to note that the filter medium removed the coliform bacteria and other nutrients either partially or completely. It was observed that as the time increased, this filter medium became more effective, in that the porosity of the filter media decreased as the particles helped clog it up, thereby increasing the treatment efficiency of effluent from the filters.

IV. CONCLUSION

This study has demonstrated a laboratory method for the treatment of raw water using pop and block. The treatment technology for small systems should have low construction and operation cost, simple operation, low maintenance, and low labor requirement as prescribed by [22].

- The effluents from pop and block used in this study were tested before and after treatment from a filter, and the pollutants at different stages have been identified with effluents that meet up NIS, WHO, and EPA standards. The filtration unit attained 98% TDS removal, 57% TSS removal, 86% Turbidity removal, 49% Temperature increase, 26% increase in pH, 91.8% of E-Coli removal and 99% of bacteria removal.
- The final effluent had a TDS and TSS close to values obtainable with some water treatment standards. The filtration process increased the Temperature and had a very small increase in pH values.
- The overall removal of faecal and total coliforms (91.8% and 99%) suggests an equivalent reduction of pathogenic organisms. This result showed that pop and blocks could improve the quality of raw water. Combination pop and block systems give a better treatment option. The adsorption capacity of the filters had an average of 90% in 48hrs. Therefore the adsorption capacity or percent efficiency increased with an increase in time. Pop could remove physical and microbial parameters due to its fine microporous structure, high adsorption capacity, and mechanical stability.
- The filter's overall performance was commendable, producing an appreciably improved quality of raw water and recommended for urban reuse, including toilet flushing, vehicle washing, landscaping, irrigation, and fire protection.
- There is a need to use this filter medium for a longer period to measure the efficiency of this filter in removing these parameters considered as well as for the tendency of its effectiveness in the removal of iron, potassium, nitrate, chloride and so on.

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