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Original Research Article

CONSTRUCTION AND TESTING OF A CONVENTIONAL WATER TREATMENT PLANT MODEL

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Abstract: Treatment and potability are essential properties of water to be considered in the design and construction of a water treatment plant model. The quest for treating raw water is important in areas facing acute shortage of potable water. This study examined how raw water can be treated via the use of a treatment plant model.

Glass, silicon sealant, diamond glass cutter, Measuring Tape, Abro2000(USA brand) stoppers, glass drilling machine, pipe and hose, aggregates and glass cleaner fluid were used in the construction of the water treatment plant model. The raw water samples were also collected from a moving stream near sewage plant at the Polytechnic Ibadan Oyo state, which was then, treated using the water Treatment plant model. The raw and treated water were characterized by carrying out laboratory analysis on the samples, the analysis were carried out at Kappa Laboratories Bodija Oyo state, Nigeria. The physical (Colour), chemical (COD, Total dissolved solid and Calcium Hardness) and microbiological (Coliform) Properties of the water samples were then tested to determine the potability of the water samples based on the model designed.

Raw and treated water samples' laboratory results were compared with the World Health Organization (WHO) standard to ascertain if the treated water is suitable for both Industrial and Domestic consumption and the results were clearly stated as follows; Untreated/ Treated ; Colour (3.3hazen units)/(0.5hazen units), COD (36.6 mg/L)/(2.8mg/L), Total Dissolved solid (622mg/L)/(165mg/L), Calcium hardness (66mg/L)/ (58), Coliform (2.2x10^2 CFUc/ml)/(Nil).

The water treatment plant model harnessed the potability properties of the raw water thereby producing water suitable for human consumption. The treatment plant should be used in Areas faced with lack of potable water.

Keywords: Treatment plant model, Portability, Coliform, World health Organisation, Microbiological Analysis.

Introduction: Water plays a prominent role on all living organism. It's a basic necessity to man, plants and other living things in existence and next to air in terms of its importance. Aside of it roles for day to day activities and demand for drinking, cooking and general sanitation purposes, water is also important with respect to Irrigation, power generation (kainji dam, shiroro dam), industrial purpose and recreational facilities. The high level of industrial and domestic pollution has caused much harmful effect on the portable water; this led the need to treat the raw and polluted water to put an end to the spread of water borne diseases, (Thompson, 1971). Ever since, nature is able to provide high quality drinking water, but contamination modification, population growth and over exploitation of the natural water resources make clean and quality water to become a scarcer commodity. To preserve this precious commodity for future generations is one of the most prominent and important tasks.

Several scientific and engineering branches such as hydrology, hydrogeology, fluid mechanics and water and waste water engineering plays a dominant role in designing our community and industrial structure for treatment of water. Suitable concepts and solutions by these branches are required. This concept has great roles with the natural processes and how this plant should be designed, operated, and controlled in a way which does not affect the hydrological cycle or cause any damage to the environment at large.

Generally in Africa there are lots of problems regarding the availability of portable water, about eighty percentages (80%) of the population which is majorly dominant in rural areas lack access to sufficient and drinkable water due to inadequate planning and cost of providing such needed structures (Population Institute 2010).The physiochemical quality is used in describing both the physical and the chemical properties and composition of water which duly will affect its portability due to defect in its colour, taste; produce toxic reactions, unexpected physiological responses of laxative effect, and objectionable effects during normal use such as curd precipitates (WHO, 2012).). Consequently, water quality can be defined by a range of variables which limit water use. Although many uses have some common requirements for certain variables, each use will have its own demands and influences on water quality. (Raymond, *et al* 1999).

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In rural Areas where there is lack of portable water an efficient and economical water treatment plant model is seen to be adopted for efficient treatment of water and the micro-organisms are disinfected or deactivated, resulting in termination of growth and reproduction (lenntech 2012).

Materials and Methods

Study Area: The raw water samples were taken from a stream near the sewage plant of the polytechnic Ibadan Oyo state Nigeria.

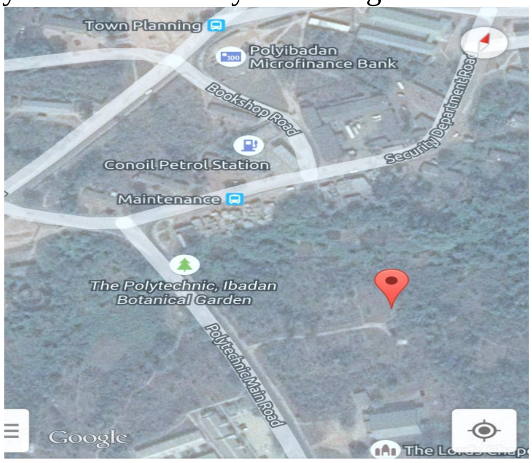


Fig.1: Map of The Polytechnic Ibadan (Source www.googleearthmap.com)

The Treatment plant was constructed and assembled in the Hydraulics laboratory of the Civil Engineering department, Polytechnic Ibadan, while the materials were purchased from Ibadan, Oyo State Nigeria.

Materials: 5 sheets of 4mm plain glass silicon sealant gum, diamond glass cutter, measuring tape Abro (2000)USA brand, stoppers, glass drilling machine, pipe and hose those were the materials and tools used. The glasses were cut into various sizes then the glass were coupled stage by stage in order to avoid mixed up with the use of paper tape sealant gum was used in coupling the glass (ABRO 2000). The diamond bit fixed with the drilling machine which is proved to be a prominent tool for drilling holes was used to drill holes on the glasses with the aid of this different sizes of holes are drilled for both the intake and outlet that will accommodate the linking holes. The equipment used for testing of the samples are; pH scanner, TDS scanner, Thermometer, Conductivity scanner, Incubator and Oven.

The installation unit is done by the arrangement of the chambers and connection of each chambers from the raw water tank down to the clear well, the raw water tank was designed to collect the raw water sample to be treated directly from the source while the Settling/ sedimentation tank is the tank where all impurities clump together after the chemicals have been added to the raw water sample which coagulates, here the coagulants and flocks settle down rapidly at the bottom of the sedimentation tank and clear water at the top moves directly into the filter bed, the Filtration tank contains the course, fine aggregate and also the activated carbon to remove the colour and odour from the water coming from the settling tank, finally the clear water tank performs the function of receiving the treated water that is, the clear water coming from the filtration tank to the community supply units.

The water sample was collected for treatment and the sample was taken to the laboratory for proper testing for the chemical (pH, alkanity, and chlorine residual and total dissolved solid), physical (temperature, colour, odour and turbidity) and microbiological properties (Coliform, BOD, COD and total viable count) of the samples.

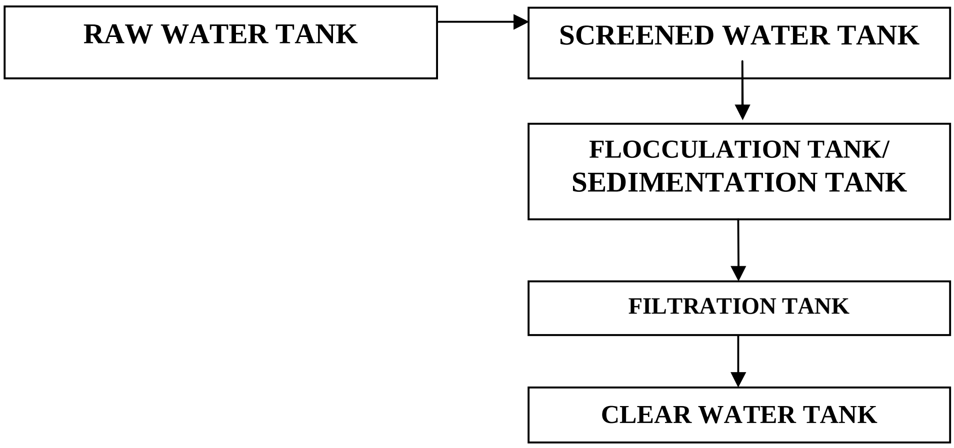
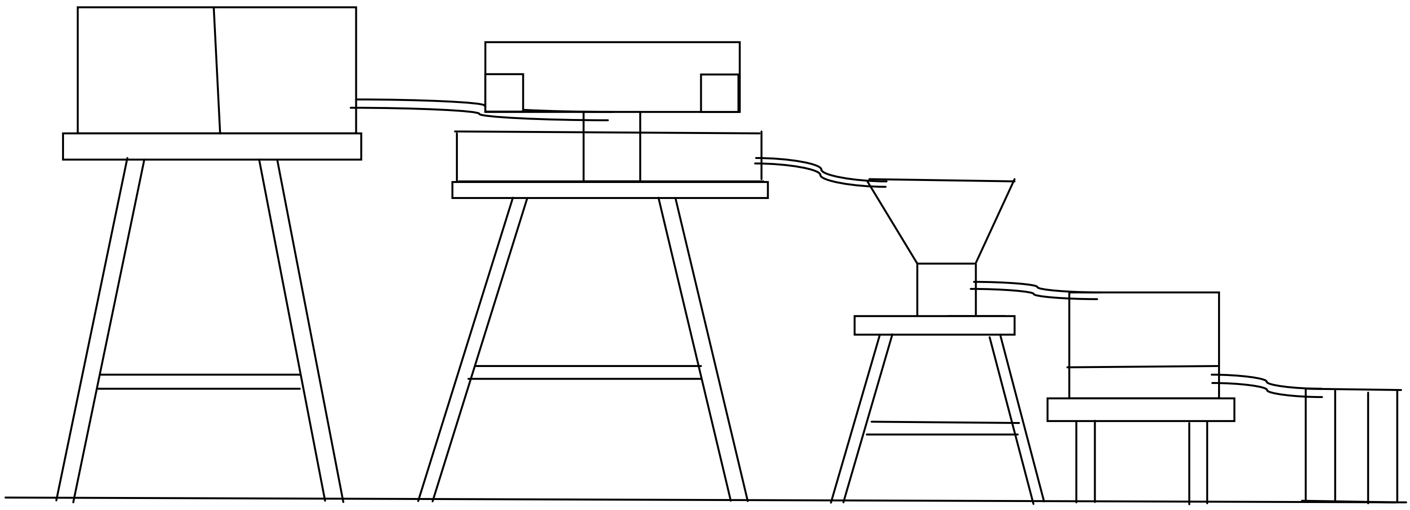


Fig. 2. Schematic Diagram of the Water Treatment Plant Model.

Plate 1.0 Construction of the Tanks

Plate 2.0 Side View of the Treatment Plant Model.



a b c d e

(a) Raw water tank/ Screened water Tank
(b) Flocculating tank
(c) Hopper bottom clarifier/ Sedimentation tank
(d) Filtrating tank
(e) Clear consumer well tank

Fig. 3. Orthographic view of the water treatment plant model

Result and Discussion: The results obtained from the laboratory analysis of both the raw water sample and the treated water sample are shown in the table below and compared with the world health organization standards (2012).

Table 1. Mean value of the laboratory result

Parameters	Raw water	Treated water	WHO standard
Colour	3.33	0.5	≤15
Turbidity (mg/L SiO_2)	4.33	1.2	≤5
Total solid (mg/L)	2175	1162	≤1500
Total dissolved solid (mg/L)	622	165	≤500
Total suspended solids (mg/L)	1553	997	
Conductivity	498	244	-
Ph	6.4	5.8	6.5-8.5
Alkalinity	1.7	0.1	≤120
Total hardness (mg/L)	78	65.5	_
Calcium hardness (mg/L)	66	58	≤500
Chloride (mg/L)	8.6	17.7	≤250
Dissolved oxygen (mg/L)	3.8	3.1	≤5.0
BOD (mg/l)	19.4	1.5	≤5.0
COD (mg/L)	36.6	2.8	
Total viable count CFUc/ml	1.9 $\times 10^3$	95 x 10^2	
Organisms identified	Bacillus spp; pseudomonas sp; flavobacteriumsp	Bacillus	
Total coliform count CFUc/ml	2.2 x10^2	Nil	Nil
Organism identified	Aeromonassp; entrbactersp	-	

Discussion: From the data collected from the analysis report of the raw and treated water from the laboratory, it was observed that the colour of the water sample dropped from 3.3 hazen units to 0.5 hazen units, also the sample's turbidity also fell from 4.3 to 1.5 both in (mg/L) as a result of the filtration, coagulation, flocculation and sedimentation processes it passed through. Also the total solid present in the water sample fell from 2175mg/L to 1162 (mg/L) as a result of the filtration procedures. From the laboratory analysis it was also observed that the total dissolved solid also reduce from 622mg/L to 165mg/L, the total suspended solid also reduced from 1553mg/L to 997mg/l after the sample was being treated due to the design of the treatment model, the conductivity also underwent a drastic decrease from 498mg/l down to 244 mg/L, the pH also reduced from 6.4 to 5.8 as a result of the chlorine added, the alkalinity also reduced also moved from 1.7 to 0.1.

Furthermore, the total hardness of the water sample also reduced from 78 to 65.5as a result of the alum added. Also the calcium hardness from 66mg/L moved to 58mg/l, the chloride presence in the raw water also increased from 8.6 mg/L to 17.7mg/L due to the chlorine added the Dissolved Oxygen drastically reduced from 8.8 to 3.1 mg/L due to exposure of water to air, the Biological Oxygen Demand (BOD) reduced from 19.4 to 1.5mg/L, the Carbon Oxygen Demand (COD) also reduced from36.6 back to 2.8mg/L due to Aeration.

From the biological analysis it was observed that the Total Viable Count reduced from 8.10 x 10^3 to 9.5 x10^2 the organism present in the water sample before treatments were; Bacillus, pseudomonas spp. Flavobacterium spp. Which was not found in treated water sample due to chlorine added, the total coliform count was 2.2 x10^2 in the raw water and was not present in the treated water sample. The tests carried out on the treated water sample all falls within the standard of the World Health Organisation due to the filtration processes it was subjected to.

Conclusion and Recommendation: The study investigates the model of water treatment plant, It is imperative that raw water is being treated either for domestic or industrial consumption. To ascertain this, series of steps are being taken in the following ways: firstly the raw water passes through screening materials, this materials screens away larger particles and debris, also the raw water passes through a coagulating tank where chemicals like potash calcium $KAlCO_4L_2$, or sodium aluminates (III) $NaAlO_2$ and lime were added for the purpose of coagulation and flocculation, here impurities clump together to form big particles, dirt or flocs which settle down rapidly. Furthermore, the water is passed through a filter bed to remove the remaining fine particles that constitutes as colour to the raw water, thereafter the filtrated water is treated with chlorine to disinfect the harmful micro organisms and germs present in the water, other chemicals that can be used in disinfecting germs present in water includes chemicals such as Iodine and fluorine Finally the treated water which is now clear and free from any form of micro-organism or germs is stored in the clear water tank ready for consumption. These processes are important because they eradicate pure water scarcity and also help in improving the properties to conform with the world health organization standards.

Though there has been several facilities that has been put in place for this treatment but the methods of treatments are obsolete due to difficulties effect of some of the materials used, the design, chemicals like chlorine are harmful to human health when consumed in large quantities thereby; de-chlorination stage should be introduced to the available facilities to reduce risk of cancer. Also proper quality control should be done, as concerning the laboratory analysis of the water sample before its been supplied to the community for consumption as no water is said to be consumable unless proper tests are being carried out to ascertain the physical, chemical and biological properties of the water sample. If all the afore mentioned are carefully put into consideration it will drastically reduce the rate of water borne disease and increase the quality of water. The study is helpful as a teaching aid for students to clearly see the model adopted and procedures involved in raw water treatment physically in the Laboratory since it's a version of a water treatment plant and as to why the glass model is much preferable to other forms of materials such metals which rusts and plastics which releases dioxins into water at a particular temperature.

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