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EFFECT OF SCHMUTZDECKE ON THE EFFICIENCY OF SAND FILTER.

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ABSTRACT

Water purification can be accomplished with a slow sand filter. The efficacy of the sand filter might change depending on the amount of schmutzdecke that forms on the sand bed's surface. The purpose of this study was to build and assess schmutzdecke's impact on sand filters' ability to effectively cleanse water. Sand served as the filter's filter media, supporting the straining and sedimentation of impurities from raw water before a biolayer formed on the sand's surface. For six weeks, filtration was done. The raw water and filtered water samples were tested for turbidity, pH, and bacterial analyses. The pH of the raw water ranged from 5.0 to 5.3, indicating that it was extremely acidic however, the pH of the effluent improved but significantly from the fourth week of filtration with a pH ranging from 7.0 to7.2 which measured up to 7.1-7.4 as WHO standard for pH of water. The raw water had the turbidity value of 16 FAU and reduced with filtration but significant reduction of turbidity was achieved from fourth filtration where the turbidity was 5FAU which met WHO water turbidity standard which should not be more that 5 FAU. Bacteriological test showed effective reduction of the E.coli up to 70% at the third filtration. Moreover, the effect of schmutzdecke became pronounced from the fourth week. There was similar result (0.7 FAU) between samples 6 and sample 7 i.e for sixth and seventh week respectively for the turbidity test and likewise the same result (7.1-7.4) with samples 5, 6, and 7 for pH test. These results suggest that the Slow Sand Filter being influenced significantly by schmutzdecke improved the water quality. Further disinfection is recommended to ensure that the best quality of portable water is obtained.

1.1 INTRODUCTION

A straightforward approach for pathogen and particle removal in drinking water purification is slow sand filtration (Langenbach et al., 2009). Additionally, biological upgrading of drinking water was tested using the slow sand filter (Aslan & Cakici, 2007).

According to Dastanaie et alstudy .'s (2007), the filter's overall performance in eliminating total suspended particles is satisfactory, and the processes identified in sand filters closely resemble those found in naturally occurring sand banks and sandy beaches (Wotton, 2002). Formation of *schmutzdecke* or colmation layer on the surface of the sand bed as filtration progresses is considered as the important process of purification mechanism of slow sand filters (Farooq, 2002). Schmutzdecke is the German word for dirty layer. It is a complex biological layer that develops on the slow sand filter's surface. The hypogeal layer, also known as Schmutzdecke, is a gelatinous layer or biofilm that is responsible for the potable water treatment process. This clingy film is made up of organic matter, iron, manganese, and silica and functions as a fine filter media to help remove turbid particles from raw water. It serves as both a starting point for biological activity and a means of lowering tastes, smells, and color in raw water by degrading some of the soluble organics in it (Tiwari et. al., 2009). After a certain number of days or weeks, it forms. It is mostly responsible for the filter's effectiveness. Foreign particles are caught and effectively chewed up by bacteria present on this biological layer as water travels through it. Impurities are left behind when the water progressively descends through the sand layers, leaving the water between 90% and 99% bacteria-free (Elliott et. al., 2008).

Schmutzdecke connects to the solid particle penetration zone, or the top 0.52 cm of a filter bed (Ranjan 2017). As food becomes more sparse, bacterial activity steadily declines with depth in the upper layer of the filter-bed. A additional ripening period is needed to raise the population of microorganisms up to the desired depth after a filter is cleaned by scraping off the top few millimeters of the filter.

For many years, the technology of slow sand filtration has been employed to filter drinkable water. Small, rural communities can readily afford it because it doesn't demand a high level of operator skill or attention. Without the need for particular skill and dexterity, it may be operated precisely. It is also run with limited financial resources. In other words, operating Slow Sand Filter is not actually hampered by financial incapacity. Because of its simplicity, people may mistakenly believe that it is an outdated technology, but in reality, it is still important today.

The aim of the research is to design and construct affordable Sand Filter and propound principle behind its effectiveness in order to provide portable water that is crystal clear from solid particles. The following are research objectives,

- To test the turbidity content of the water samples.
- To test the pH value of the water samples.

This study focused only on using readily accessible plastic buckets, pipes, and taps to make slow sand filters. It was limited to the use of fine sand, which was easily accessible. The fine sand was extensively cleaned to remove any additional particles besides those that would be captured from the water sample. The water came from a well as its source.

According to observations, well water and tap water (which is pumped from a well) are the main sources of drinking water, and the water from these sources typically contains particles. Additionally, the town's (Offa town) surrounding roads—more than 60% of which are unpaved—produce a lot of dust and particulates. The goal of this study project was to address this issue, resolve the turbidity issue, and provide strategies for effectively providing clean water for ourselves.

2.1 Water

Water is a tasteless, odorless, transparent liquid that, in small amounts, is colorless but, in big amounts, has a bluish tinge. It is the most well-known and plentiful liquid on planet. About 70% of the surface of the globe is covered with it in liquid and solid form (ice). It is in the atmosphere in variable degrees. Water makes up the majority of a human's living tissue, accounting for 92% of blood plasma, 80% of muscle tissue, 60% of red blood cells, and more than half of the majority of other tissues. Water is also a vital component of the tissues. It plays a significant role in the tissues of the majority of other living things (Biswas, 2000). Liquid water contains three different types of populations of molecules Due to the enormous thermal energy of the molecules, single molecules are the norm at the highest temperatures with negligible hydrogen bonding. More hydrogen bonds develop and molecule clusters form in the medium range of temperatures.

Cluster aggregates can also form at lower temperatures; at about 150C, these aggregates are the most prevalent configuration. Many elements of the peculiar behavior of water can be explained in terms of these three population categories and the transitions between them. For instance, the increased number of molecules in water causes it to tend to freeze more quickly when cooled quickly from a relatively warm temperature than when cooled at the same pace from a lower temperature aggregates in a cluster, in the cooler water, that are oddly shaped and must find a way to fit with one another (Stauber et al., 2006). The structure of water is responsible for a lot of its physical and chemical characteristics. Instead of being on the exact opposite sides of the oxygen atom, the two HO bonds between the atoms in the water molecule are positioned at an angle of about 1050.

2.2 Properties of Water

Chemical properties

Numerous chemical reactions can occur in water. The ability of water to function as an acid (a person donor) and a base (a person acceptor), the defining quality of atmospheric substance, is one of the most significant of water's chemical qualities. The most obvious example of this activity is when water ionizes on its own.

$H_3O^+(aq) + OH^- = H_2O(L) + H_2O(L)$ (aq) … ….. I

The twin arrows show that the reaction can happen in either direction and that an equilibrium condition exists. The (L) denotes the liquid state, the (aq) denotes that the species are dissolved in water. The amount of hydrated H^+ (H_3O^+, also referred to as the hydronium ion) in water is 1.0x10-7 M at 25 oC (77 oF), where M signifies moles per liter. Since each produces a single OH^- ion H_3O^+ ion, and at 250C, OH^- concentration is also 1.0x10-7.

Both the acid and the water both contribute H^+ ions to the solution when an acid (a chemical that may make H= ions) is dissolved in water. As a result, there is an instance when the H^+ concentration is higher than 1.0x10-7 M. Since (H^+)(OH^-) = 1.0x10-14 at 250C must always be true, the OH must be reduced to a value lower than 1.0x10-7. The reaction H^- + OH^- H_2O, which happens to the extent required to restore the product of H^+ and OH^- to 1.0x10-14 M, is the mechanism for lowering the concentration of OH^-. The resultant solution then includes more H^+

than OH- when an acid is added to water, indicating that H+ > OH. Such An acidic solution is one in which (H+) > (OH-).

A powerful exothermic (heat-producing) reaction takes place when an active metal, such as sodium, comes into contact with liquid water, releasing burning hydrogen gas.

The equation is $2Na(s) + 2H_2O(L) = 2Na^+(aq) + 2OH^-(aq) + H_2(g)$ (ii)

In an oxidation-reduction reaction, when electrons are moved from one atom to another, this is an illustration. In this instance, hydrogen gas and OH+ ions are created by the transfer of electrons from sodium atoms (producing Na+ ions) to water molecules. The reactions of the other alkali metals with water are comparable. Less reactive metals take longer to react with water. For instance, iron reacts with liquid water very slowly but reacts quickly with superheated steam to produce iron oxide and hydrogen gas.

$3Fe(s)$ plus $4H_2O(g)$ equals Fe_3O_4 plus $4H_2(g)$ (iii)

Silver and other noble metals don't interact with water at all (Diersing, 2009).

2.2.2 Physical properties

• The temperature, color, turbidity, odor and taste, and solid content are the physical characteristics of water. The barometric pressure affects the boiling point of water and all other liquids. For instance, water boils at 680oC (1540oF) at the summit of Mount Everest as opposed to 100oC (2120oF) at sea level. On the other hand, water near geothermal vents deep in the ocean can reach temperatures of hundreds of degrees while still remaining liquid. Due to the substantial hydrogen bonding between its molecules, water has a high specific heat capacity (4181.3j (Kg/K)) and a high heat of vaporization (40.65 KJ/mol). Due to these two peculiar characteristics, water may regulate the climate of the planet by absorbing significant temperature changes. Water's highest density is found at 3.980C (39.160F). When chilled to the point where ice forms, it has the peculiar trait of being less dense rather than more so (Diersing, 2009).

• When water freezes, the ice's open structure gradually breaks down, allowing molecules to enter the cavities of the water's ice-like structure. Two competing effects exist. There are two effects that conflict:

1) Increasing the amount of regular liquid.

2) A decrease in the liquid's total volume.

The second impact will balance out the first effect between 0 and 3.980C, resulting in a net effect of volume contraction within temperature. In its solid state, ice expands to fill 9% more volume, which explains why icebergs can float on liquid water. Liquid has a density of 1 000 kg/m3 at 40C. The density of ice is 917 kg/m3. In all ratios, water is miscible with man-made liquids like ethanol, resulting in the formation of a single homogeneous liquid. In contrast, water and the majority of oils are immiscible and often layer according to increasing density. Water vapor is totally miscible with air when it's a gas (mann et. al., 2007).

- **Taste and Odour**

Water may dissolve a wide range of chemicals, giving it a variety of flavors and scents. By avoiding water that is overly salty or rotten, humans and other animals have acquired senses that allow them to assess the portability of water. The minerals dissolved in spring water and mineral water give it their distinct flavors, which are frequently promoted in consumer product marketing. Pure water, on the other hand, has no flavor or odor. As opposed to the absence of naturally occurring minerals, the stated purity of spring and mineral water refers to the absence of poisons, contaminants, and germs.

- **2.3 Sources of Water**

The methods for gathering water are countless. Here are the primary sources discussed:

• Surface Water: This is the water that rains or hails and falls on the earth. This water is gathered from a particular region known as the catchment. The water is subsequently kept in a dam or reservoir, which are barriers that might be man-made or natural. Dams are typically built near a valley's bottom. In order to reduce the possibility of the water being in catchment areas and on dams and to ensure that water supplies are kept potable, catchment areas are typically located distant from towns and cities.

• **Lakes and rivers**: Towns and communities occasionally draw their water supplies straight from surrounding lakes and rivers.

• Springs: These are located where there is subterranean water without the usage of boreholes, wells, or pimps, the water spontaneously seeps out of the earth. Springs frequently appear at the base of hills or on slopes.

• Rock catchment regions and rockholes: Sometimes, there are substantial rocky outcrops in low locations where water collects. They can be used as effective natural dams. A wall can frequently be erected to increase the volume of water trapped.

• Excavated Dams: To create an excavated dam, a large, shallow hole is created by scooping out soil. Sometimes the bottom of a slope will have one of these dams to help collect water. This is

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only possible in places where the soil prevents water from simply draining away through the earth. such as in clay soil that is said to be impermeable if it prevents water from draining away.

Filtration

The top of the filter is where clarified water enters. Water passes through the filters and is collected in a drain system at the bottom of the device as a result of gravity. Filters can be made using a wide variety of materials (media). The most popular ones are gravel and sand. Granular activated carbon is now the media of choice for many conventional plants since it not only offers great mechanical filtration of particulate matter but also eliminates organic compounds that might lead to taste and odor issues.

• Sand Filter, Slow

For hundreds of years, drinking water has been filtered using the Slow Sand Filtration technique. In order to create a portable product, it is utilized to treat raw water throughout the water purification process. They are typically used to treat surface and ground water and can have a rectangular or cylinder-shaped cross section. The desired flow rate for the filters, which normally has a loading rate of 0.1–0.2 m/hour, determines the length and width of the tanks (AWWA, 1991).

The constructed sand filter

3.0 Equipment/Apparatus

Equipment/Apparatus

The apparatus used for the execution of this sand filter includes the following:-

●Plastic container: ●Lid: ●Outlet pipe: ●Water level ●Drainage gravel: ●Separation gravel: ●Filtration sand: ●Colorimeter: ●Flow Regulator ●pH meter: ●Sampling Bottles: ●Graduated Cylinder. ●Conical flask. ●Sample cells

Laboratory Test

3.3.1 Turbidity test

This was carried out to determine the degree of cloudiness or haziness of both samples (raw and filtered water) caused by suspended solids that are usually visible or invisible to the naked eye. Colorimeter equipment was used to carryout the turbidity test. The raw water sample was obtained from a Well at Nawarudeen Nursery and Primary School, along Alheri Sawmill, Offa.

3.3.2 pH test

This was done to figure out how acidic and alkaline the treated water and the raw water were. A pH meter was used to conduct this experiment.

3.3.3 Bacteriological analysis

This was accomplished by estimating the coliform bacteria using the coli most likely number. Three pieces of each dilution in a geometric series were used to perform the most likely number (MNP) of coliform presumptive test on each test sample while using single and double strength lactose broth.

Filtration Process

Raw water is supplied to the filter via a diffuser plate after the layers of sand and gravel have been added. A combination of biological and physical processes occur in the biofilm layer and the sand layer to remove pathogens and suspended particles. Mechanical trapping, predation, absorption, and natural death are some of these methods (CAWST, 2009).

4.1 Turbidity Removal

Seven samples, including the raw water, will be analyzed because the water was filtered for six weeks in a row. When compared to the World Health Organization turbidity standard, which states that the turbidity of drinking water should not be more than 5 NTU but should ideally be below 1 NTU, the results of the turbidity on the raw water and treated water samples showed a slight gradual reduction on the turbidity level, but significant reduction began at the third week. According to Buzuniz's 2005 report, the schmutzdecke layer in sand filters begins to significantly reduce turbidity after three to four weeks of filtration. The filter media's pores contain a staining process that helps to remove turbidity. Large enough particles to fit At the sand surface, the spaces between the sand grains are strained out. As debris builds up, the sand surface's pore opening shrinks, allowing increasingly smaller debris to be removed by straining. The considerable clearance of the particles is mostly caused by the particle buildup to produce schmutdecke.

TABLE 4.1: Result on the turbidity of the raw and filtered water samples

SAMPLES	TURBIDITY (FAU)
1 (week 1)	16
2 (week 2)	14
3 (week 3)	13
4 (week 4)	5
5 (week 5)	2
6 (week 6)	0.7
7 (week 7)	0.7

4.2 E.Coli Removal

The results of the bacteriological investigation of the water sample revealed that the raw water contained high levels of E. coli. The coliform had been eliminated, according to further analysis of the water samples, but considerable coliform removal of up to 70% began with the week four filtered sample.

Pathogenic microorganisms are primarily eliminated through death and predation. The bacteria are preyed upon by the organism colonized in the Schmutzdecke layer, a biological layer that formed over the top of the filtering media in the third to fourth weeks. As the organic matter in the influent water is caught on the layer and eaten by the bacteria colonized in Schmutzdecke, the pathogens suffer as a result of a lack of food in the filter. (Buzuniz, 2005).

4.3 pH Treatment

The results obtained from the pH test carried out on the samples showed an improvement in the pH quality of the water after the filtration.

The initial pH reading recorded was in the range of 5.0-5.3 which implies that the water is acidic and unsafe for consumption. After filtration, the pH value obtained for the fourth week was in the range of 7.1-7.4 which meets the WHO standard for the required pH for portable water.

Table 4.2: Result for pH test

SAMPLES	pH VALUE
1 (week 1)	5.0-5.4
2 (week 2)	5.2-5.5
3 (week 3)	5.5-6.8
4 (week 4)	7.0-7.2
5 (week 5)	7.1-7.4
6 (week 6)	7.1-7.4
7 (week 7)	7.1-7.4

Conclusion

The purpose of this study is to propound the principle behind the effectiveness of sand to provide water that is clear from solid and turbidity. The evolution of the performance of the sand filter gave the significant reduction of bacteria up to 70% from the third week of filtration as well as reduction of turbidity to WHO water turbidity standard level.

The effectiveness of the sand fitter from the third week was as a result of the biological layer of dirts (Schmutzdecke). Therefore, the performance of the sand filter depends majorly on the maturity of the biolayer (Schmutzdecke) and it takes about 3-4 weeks for the biolayer to fully mature. The results of the bacteriological investigation of the water sample revealed that the raw water contained high levels of E. coli. Additional examination of the water samples revealed the presence of the coliform. The layer of the microbial community known as Schmutzdecke is in charge of filtration the water through the sand bed. Foreign objects are caught and effectively digested by bacteria that grow on this biological layer as water travels through it. The availability

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of bacteria in the raw water, the availability of food, oxygen, the length of stay, and wetting of the sand bed all play a role in the development of the schmutzdecke layer. Its growth is reliant on the organic materials in raw water.

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