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Filtration process with tilapia fish scale macrocomposite adsorbent for groundwater treatment

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Abstract: In this study, a filtration column with tilapia fish scale macrocomposite adsorbent was used to treat groundwater from a tube well in an indigenous village located at Kangkar Senangar, Parit Sulong. The tilapia fish scale macrocomposite adsorbent was prepared by mixing tilapia fish scale powder with cement and calcium carbonate in a cube mould. Next, the tilapia fish scale macrocomposite adsorbent was characterised for Scanning Electron Microscope (SEM), Energy Dispersive X-ray (EDX), and Fourier-Transform Infrared spectroscopy (FTIR) analyses. SEM analysis displayed an irregular and porous surface in the fish scale powder while EDX analysis detected the major elements of the adsorbent which are oxygen, calcium, and carbon. FTIR analysis of the tilapia fish scale adsorbent showed the presence of hydroxyl, carbonyl, and alkene groups that are responsible for the adsorption process. For the filtration column, a layer of dried sand and gravel was cleaned and packed in the column. The filtration test was carried out with and without the tilapia fish scale macrocomposite adsorbent. The adsorbent was then tested in a real filtration system at the village site. The water sample was measured for pH, dissolved oxygen, turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), total dissolved solid (TDS), ammonia nitrogen (AN), total hardness and heavy metals before and after filtration process based on with and without tilapia macrocomposite adsorbents. The results showed that the sand filter with tilapia fish scale adsorbent had better removal efficiency with more than 92.53% turbidity, 81.82% COD, 83.33% TSS, 88.89% TDS, 95.24% AN, 90.30% manganese and 89.50% zinc removal in groundwater.

Keywords: Filtration process, tilapia fish scale, macrocomposite, adsorbent ,groundwater treatment

1. Introduction

Here introduce Groundwater is one of the most important natural resources that are naturally protected against pollution by filter layers of rocks and soil [1]. Groundwater irrigation provides a more secure source, less susceptibility to drought and easier access for personal use compared to conventional methods of irrigation for surface water [2]. Contaminated groundwater cannot be used for drinking because of the presence of anions such as chloride and sulphate as well as heavy metals such as lead and copper that can pose significant health risks to humans [3]. The contaminants that degrade the quality of groundwater can be classified into two categories according to their source, which are natural and anthropogenic pollutants such as pesticide applications, and land and waste from animals [4]. Some of the treatments that can be used to increase groundwater quality include aeration, filtration, and chlorination. Water filtration is the process of eliminating or reducing the concentration of particulate matter in polluted water, including suspended particles, chemical, and biological contaminants to produce safe and clean water [5]. Despite the many forms of media that can be applied as a filter, some can be made from natural materials [6]. Gravel is commonly used to screen out debris and dirt prior to the next treatment process. River sand possesses a fineness modulus of 2.32 and particle sizes ranging from 0 to 4.75 mm, which is ideal for use as a slow sand bed filter [7]. In addition to that, tilapia fish scale macrocomposite adsorbent can be used in the filtration system as a filter media. Tilapia fish scales are easily obtained from the market and fish processing industries. Fish scales can be reused as raw material or processed into useful goods, resulting in less environmental impact and efficient management of fish waste [8]. Ion exchange, dissolution–precipitation, and surface complexation are the potential adsorption mechanisms of using fish scale adsorbent [9]. The fish scale adsorbent has been found to have excellent removal

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efficiencies and adsorption capability for heavy metals (50-100%), dyes (78-90%), and pharmaceutical compounds such as nitrate[10]. Fish scales can act as adsorbent with cement as a binder and calcium carbonate as thermal conductivity to produce macrocomposite adsorbents. This study will determine the characteristic of the tilapia fish scale macrocomposite adsorbent and investigate the performance of the filtration system with and without the tilapia fish scale macrocomposite adsorbent for groundwater treatment.

1.1 Scope of Study

This study is conducted to determine the efficiency of tilapia fish scale macrocomposite adsorbent to treat groundwater. The macrocomposite adsorbent is produced by mixing the ground tilapia fish scale with cement, calcium carbonate, and water. The groundwater sample was collected in a high- density polyethylene (HDPE) container from a faucet that was connected to the pump and tube well as shown in Figure 1. Then, the container was stored in a chiller room at the Environmental Engineering Technology Laboratory, Universiti Tun Hussein Onn Malaysia, Pagoh prior to being used in the experiment. The collected water sample was filtered in a filtration column and real sand filtration system at the site with and without the tilapia fish scale macrocomposite adsorbent to investigate the effectiveness of the water treatment process. The parameters tested include pH, dissolved oxygen (DO), turbidity, total dissolved solids (TDS), total suspended solids (TSS), chemical oxygen demand, biological oxygen demand (BOD) and nitrogen ammonia (AN). The heavy metals in the water sample are tested using inductively coupled plasma mass spectrometry (ICP-MS).

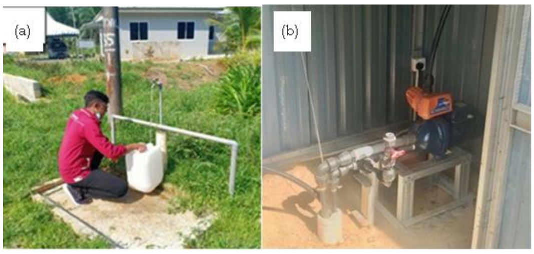

Figure 1: Groundwater sample collection from (a) faucet connected to the (b) pump of the tube well.

1.2 Tables

In order to accomplish the study objectives, the flowchart methodology as represented in Figure 2 was used to obtain the information.

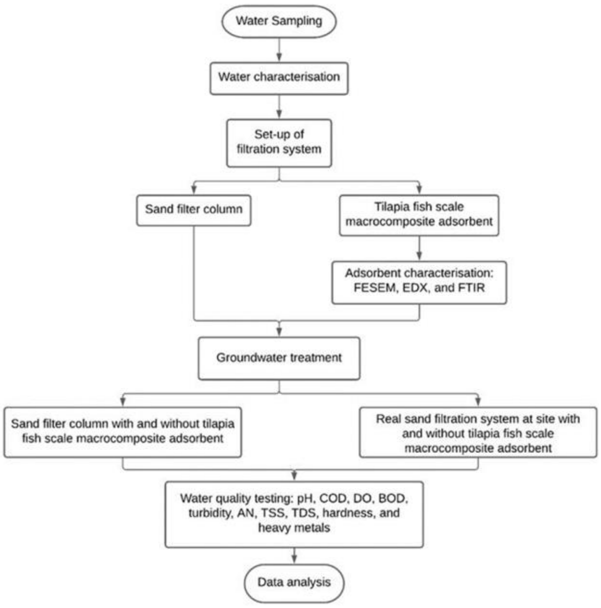

Figure 2: Flowchart methodology of this study.

1.3 Preparation of tilapia fish scale macrcocomposite adsorbent

About 5 kg of tilapia fish scales were purchased from China, which were processed and dried. A mortar grinder set to 500 rpm was used to grind the dried fish scales every 30 minutes. Figure 3 shows the tilapia fish scale powder after being sieved. The tilapia fish scale macrocomposite adsorbent was produced by a mix ratio 3:1:1 of cement, calcium carbonate, and tilapia fish scale powder. The water cement-ratio of 0.65 was used to produce tilapia fish scale macrocomposite adsorbent. Next, the wet mixture was cast into a rectangular mould with a dimension of 4.5 cm x 4.5 cm x 4.5cm and left to harden for 24 hours. Then the adsorbent was cured for 7 days to reduce the amount of water that is lost from the surface of the adsorbent when it is mixed. After that, the adsorbents were dried for 1 day. Figure 4 shows the tilapia fish scale macrocomposite adsorbent.

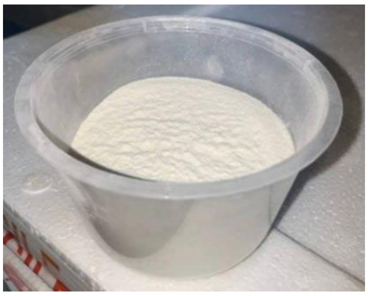

Figure 3: The tilapia fish scale powder after sieved.

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Figure 4: The tilapia fish scale macrocomposite adsorbent.

1.4 Set-up of filtration system

The set-up of the filtration system consists of a feed tank, treated water tank, connecting tube, filtration column, and a ball valve tap. The feed tank was filled with the collected groundwater sample. Then, the valve was opened to direct the water into the filter column under gravity. After that, the water sample was filtered in the filtration column. The experiment was carried out with and without the tilapia fish scale macrocomposite adsorbent in the filter column. The experiment was carried out at the site of the filtration system project in an indigenous village in Kangkar Senangar. In tanks 1 and 2, there were filter media that consisted of fine sand, coarse sand, and gravel. The source of the water sample came from groundwater that was pumped through a tubewell. Initially, the water sample was taken from the sand filtration without any adsorbent in tanks 1 and 2. The tilapia fish scale macrocomposite adsorbents were ttplaced in tank 1 for several days. The schematic diagram placement of tilapia fish scale macrocomposite adsorbents in tank 1 is shown in Figure 5. The water sample was collected before and after the treatment to be analysed. The removal of turbidity, AN, TSS, TDS and heavy metal is calculated by Eq. 1 below:

$$\text{Removal efficiency (\%)} = \frac{Ci\ (mg/l) - Cf\ (mg/l)}{Ci\ (mg/l)} \times 100\ \%$$

Where Ci is initial concentration and Cf is final concentration

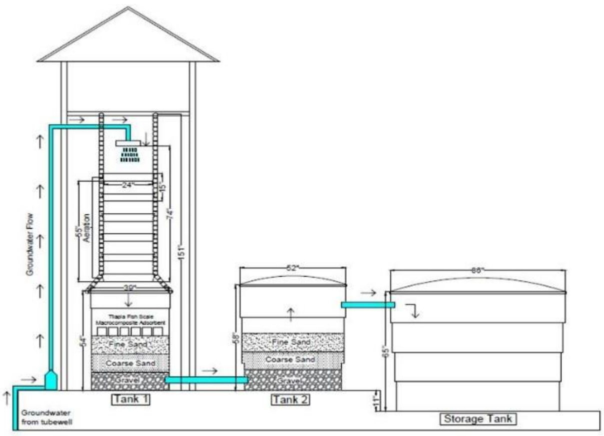

Figure 5: Schematic diagram placement of tilapia fish scale macrocomposite adsorbents in tank 1.

1.5 Surface morphology and element composition

Avoid hyphenation The surface morphology of tilapia fish scale macrocomposite adsorbent before and after the groundwater treatment is shown in Figure 6 and Figure 7, respectively. From Figure 6, the surface of the adsorbent consists of a porous and irregular surface structure due to the fish scale powder[11]. The micrographs show two zones of fish scale powder in adsorbent, one white and the other darker. The white zone includes inorganic material such as calcium, while the dark zone contains protein due to the high concentration of carbon and oxygen [12]. Figure 7 shows the surface of tilapia fish scale macrocomposite adsorbent after groundwater treatment. Due to metal ions and impurities trapped in the pores, the surfaces are damaged, rough, and asymmetrical in structure[13]. The major chemical composition of the adsorbent before groundwater treatment consists of 61.8% oxygen (O), 17.87% carbon (C), 14.07% calcium (Ca) and 3.65% silicon (Si). After the groundwater treatment process, the major chemical composition of the adsorbent consists of 54.16% oxygen (O), 33.12% carbon (C), 8.98% calcium (Ca) and 2.15% silicon (Si). The surface groups containing a high concentration of oxygen could strengthen the interaction between the tilapia fish scale adsorbent and the carbon surface via the formed hydrogen bond or van der Waals force, thereby significantly increasing the adsorption strength [14].

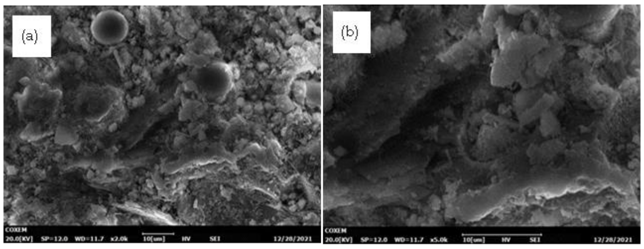

Figure 6: SEM morphology of tilapia fish scale macrocomposite adsorbent before groundwater treatment at (a) 2000x and (b) 5000x magnification.

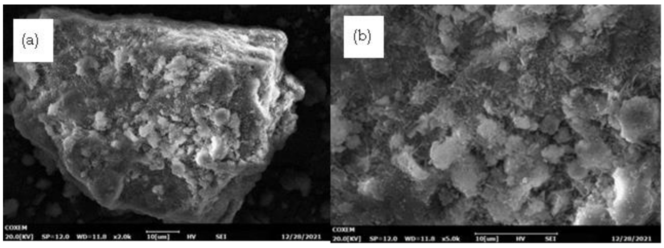

Figure 7: SEM morphology of tilapia fish scale macrocomposite adsorbent after groundwater treatment at (a) 2000x and (b) 5000x magnification.

1.6 Fourier transform infrared spectroscopy (ftir)

The FTIR study was performed before and after groundwater treatment utilising the tilapia fish scale macrocomposite adsorbent. Figure 8 shows the FTIR spectrum of tilapia fish scale macrocomposite adsorbent before and after groundwater treatment respectively. Based on Figure 8 (a), the FTIR spectrum of tilapia fish scale macrocomposite adsorbent before the treatment shows the peak located at 3409.19 cm-1 as the presence of a stretching weak hydroxyl (-OH) group. The peak located at 1410.77 cm-1 was allocated to the OH stretching in-plane and the C-H stretching in the symmetrical region of the adsorbent [15]. In addition, the peak located at 965.17 cm-1 and 872.75 cm-1 indicated the presence of the O-P-O symmetric stretching vibrations in the PO43- groups and the O-H stretching mode [16].

The FTIR spectrum of tilapia fish scale macrocomposite adsorbent after treatment in Figure 8 (b) shows the peak decrease from 3409.19 cm-1 to 3394.99cm-1 in the presence of a stretching weak hydroxyl (-OH) group. Hydroxyl groups can establish hydrogen bonds with water, which boosts the hydrophilicity and solubility of molecules that contain ions [17]. Then, the peak from 1410.77 cm-1 increased to 1411.07 cm-1 , representing the carbonyl COO group accepting zero or one H-bond [18]. The alkene functional group of the adsorbent before groundwater treatment was detected at 965.17cm-1 and had increased to 967.76 cm-1 after groundwater treatment, which showed the trans- alkene absorption. The adsorption energies of alkenes are significant functions of hydrogen coverage as the adsorption of organic molecules [19]. The bands at 870.46 cm-1 revealed the presence of the carbonate ion in the adsorbent [20]. Adsorption of carbonate ions was caused in the exchange of surface groups with carbonate groups, resulting in an increase of the negatively charged groups on the zinc oxide surface [21].

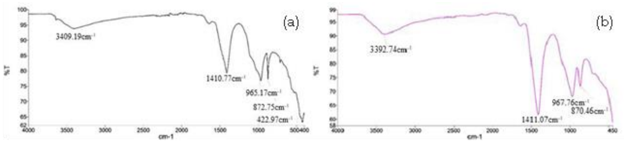

Figure 8: FTIR spectrum of tilapia fish scale macrocomposite adsorbent (a) before and (b) after the groundwater treatment.

1.7 Effect of filtration with and without tilapia fish scale macrocomposite adsorbent in a column study

The results of the effect filtration system with and without the tilapia fish scale macrocomposite adsorbents in a column study were tabulated for pH, DO, turbidity, COD, BOD, TSS, TDS, AN, and total hardness as shown in Figure 9 to Figure 11. Figure 9(a) shows pH concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial pH of the groundwater was 5.67 before the treatment. Then, the pH increased slightly to 5.84 after the sand filtration without the adsorbent, while the pH rose to 6.23 after the sand filtration with the adsorbent. Increased pH values in groundwater were linked to the sorption of OH- groups on adsorbent surfaces and the subsequent release of OH- groups during ligand exchange filtrations[22].

Figure 9(b) illustrates the DO concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial DO concentration was 6.92 mg/L before the treatment. Then, the DO concentration was rise to 8.75 mg/L after using the sand filtration without adsorbent while for sand filtration with adsorbent, the DO concentration increased to 8.93 mg/L. Figure 9(c) displays the BOD concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial BOD reading of

the groundwater sample was 2.63 mg/L before the treatment. Then, the reading of the groundwater sample was 2.63 mg/L before the treatment. Then, the reading BOD increased slightly to 3.23 mg/L after using the sand filter without an adsorbent. The reading BOD by sand filter with adsorbent also rose to 3.21 mg/L. High BOD after the treatment might be due to the formation of a biological film on the sand filter and adsorbent surface that increase the oxygen consumption and degradation of organic compound in water by microorganisms [23].

The turbidity removal from the sand filters with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent is demonstrated in Figure 10(a). The initial turbidity of the groundwater sample was 8.18 NTU. After the sand filtration with adsorbent, high turbidity removal of 16.29% was attained compared to the sand filter without adsorbent, with only 11.73% removal. Figure 10(b) shows the COD removal from the sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial COD of the groundwater sample was 18 mg/L. After the sand filtration with adsorbent, high COD removal of 38.89% was achieved compared to the sand filter without adsorbent with only 16.67% COD removal. Figure 10(c) shows the TSS removal from the sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial TSS of the groundwater sample was 8 mg/L. High TSS removal of 75% was obtained from the sand filter with adsorbent, while TSS removal for sand filter without adsorbent was 40%.

The TDS removal from sand filters with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent is shown in Figure 12. High TDS removal of 32.89% was obtained from the sand filter with adsorbent compared to sand filter without adsorbent with only 6.85% TDS removal. Figure 12(a) shows the ammonia nitrogen concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial AN of the groundwater sample was 0.38 mg/L. The reading increased to 0.39 mg/L and 0.42 mg/L after using a sand filter without and with adsorbent, respectively. The increase in ammonia could be a result of organic nitrogen being hydrolysed to NH4 under anaerobic conditions. NH4 is converted to NO3 in aerobic conditions thus increasing the ammonia content in the water [24].

Figure 12(b) shows the total hardness concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent. The initial total hardness of the groundwater before treatment was 7.33 mg/L CaCO3. After the treatment, the total hardness increases to 9.21 mg/L CaCO3 and 9.34 mg/L CaCO3 for sand filters without and with adsorbent, respectively. This might be due to the content of multivalent cations such as calcium and magnesium ions in the sand filter and macrocomposite adsorbent that may have leached in the water which consequently increased the total hardness [25].

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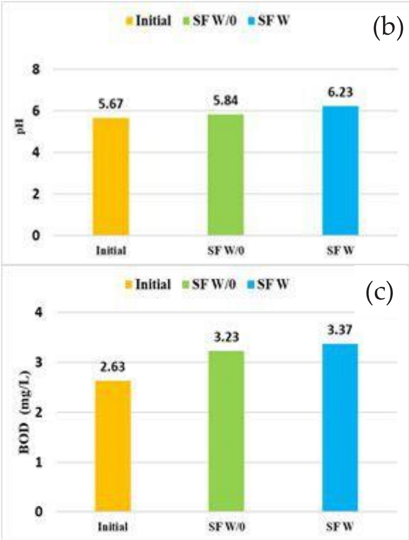

Figure 9 : (a) pH, (b) DO concentration and (c) BOD concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent.

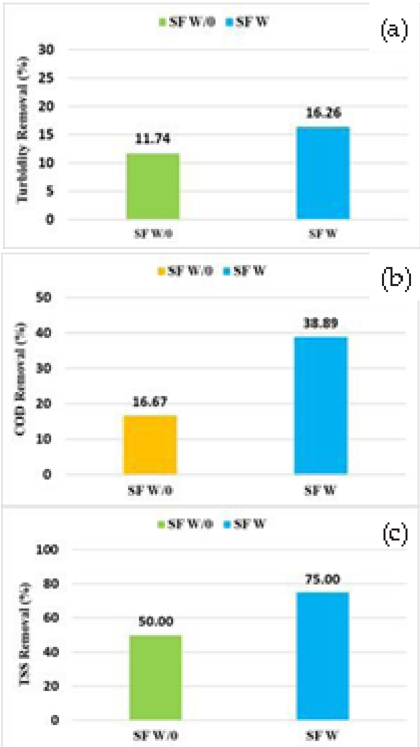

Figure 10: (a) Turbidity, (b) COD, and (c) TSS removal from sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent.

Figure 11: TDS removal from sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent.

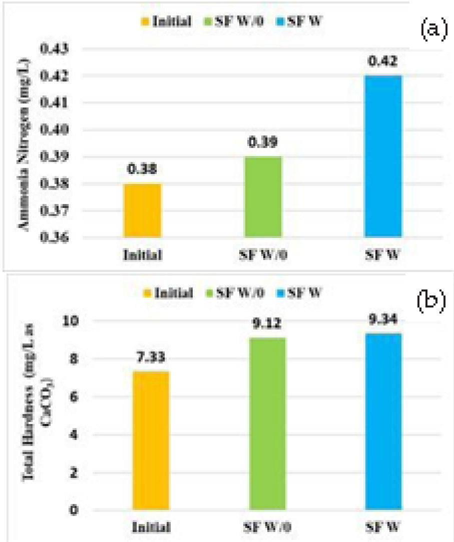

Figure 12: (a) Ammonia nitrogen and (b) total hardness concentration in groundwater and sand filter with (SF W) and without (SF W/O) tilapia fish scale macrocomposite adsorbent.

2. **Effect of filtration with and without tilapia fish scale macrocomposite adsorbent in real filtration system on site**

The results of the effect filtration system with (tank 1) and without (tank 2) the tilapia fish scale macrocomposite adsorbent in a real filtration system at the site of an indigenous village in Kangkar Senangar were tabulated for pH, DO, turbidity, COD, BOD, TSS, AN, total hardness and heavy metals as shown in Figure 13 to Figure 17. Figure 13(a) shows pH concentration in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. The initial pH of groundwater before the filtration process was 5.68 and 5.72 for 1 day and 5 days, respectively. The initial pH of filtered water without adsorbent was 5.74, and after the sand filtration process without adsorbent in tank 1, the pH rose to 7.28. After the groundwater flow into tank 2 for a second sand filtration process, the pH increased to 7.5. On the other hand, the initial pH of filtered water with adsorbent for the first day was 5.72. After the sand filtration process with adsorbent in tank 1, the pH rose to 7.5. Then, the pH increased to 7.75 after sand filtration in tank 2. After 5 days, the initial pH of the groundwater in the tubewell was 5.68. The pH increased to 7.43 after the sand filtration process with adsorbent in tank 1. The pH increased slightly to 7.74 after sand filtration in tank 2.

The DO concentration in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days is shown in Figure 13(b). For sand filters without adsorbent, the initial DO concentration was 6.61 mg/L. The DO concentration increased to 7.93 in tank 1 and tank 2. For the sand filter with adsorbent, the initial DO was 5.25 mg/L and 4.36 mg/L after 1 day and 5 days, respectively. The DO concentration rose slightly to 5.84 mg/L and 6.46 mg/L in tank 1 and tank 2 respectively after 1 day. The DO

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concentration increased from 4.36 mg/L to 7.87 mg/L after 5 days in tank 1 and tank 2. The increase of DO might be due to the aeration process that occurs due to the water that falls via gravity into the tank, thus increasing the oxygen content in the water over time [26]. Figure 13(c) shows the BOD concentration in the tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. For the sand filter without adsorbent, the BOD in tank 1 and tank 2 increased to 1.4 mg/L and 1.81mg/L, respectively. The BOD for sand filter with adsorbent after 1 day was decreased to 3.01 mg/L in tank 1 and rise to 3.20 mg/L in tank 2. After 5 days, the BOD in tank 1 decreased to 2.90 mg/L while rose to 3.39 mg/L in tank 2.

Figure 14(a) illustrates the turbidity removal in the sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. Overall, the turbidity removal in groundwater samples from the sand filter with adsorbent was higher than the sand filter without adsorbent. For the sand filter without adsorbent, the turbidity removal in tank 1 was 25.97% and rise to 86.27% after sand filtration in tank 2. The turbidity removal for sand filter with adsorbent after 1 day was 40% in tank 1 and rose to 92.53% in tank 2. After 5 days, the turbidity removal in tank 1 increased to 76.83%, while a slight increase in removal to 90.24% was observed in tank 2. This is more effective compared to the sand filter without adsorbent. The increasing turbidity removal was due to negatively charged functional groups attracting positively charged contaminants, resulting in adsorption of the compound to the adsorbent surface. All the final results after the treatment in tank 2 were around 1.24 NTU and achieved the permissible limit for turbidity, which should be below 5 NTU under Drinking Water Quality Standards.

The COD removal in sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days is shown in Figure 14(b). Overall, the COD removal in groundwater samples from the sand filter with adsorbent was higher than the sand filter without adsorbent. For the sand filter without adsorbent, the COD removal in tank 1 was 4.35% and rise to 56.52% after sand filtration in tank 2. The COD removal for sand filter with adsorbent after 1 day was 22.22% in tank 1. However, the COD removal dropped to 0% in tank 2 after 1 day. After 5 days, the COD removal in tank 1 and tank 2 increased to 68.18% and 81.82%, respectively. This is more effective compared to the sand filter without adsorbent.

Figure 14(c) illustrates the TSS removal in sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. For the sand filter without adsorbent, the TSS removal in tank 1 was 69.23% and rose to 84.62% after sand filtration in tank 2. The TSS removal for sand filter with adsorbent after 1 day was 33.33% in tank 1 and increased to 83.33% in tank 2. After 5 days, the TSS removal in tank 1 increased to 50%, while a slight decrease to 75% was observed in tank 2. This shows that the TSS removal was lower after the first day, but increased after a few days.

Figure 15(a) depicts the TDS removal in the sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. Overall, the TDS removal in the groundwater samples from the sand filter with adsorbent was higher than the sand filter without adsorbent. For the sand filter without adsorbent, the TDS removal in tank 1 was 53.85% and rose to 80.77% after sand filtration in tank 2. The TDS removal for sand filter with adsorbent after 1 day was 61.11% in tank 1 and increased to 88.89% in tank 2. After 5 days, the TDS removal in tank 1 increased to 62.5%, while a slight increase of removal to 75% was observed in tank 2. Increased TDS removal was due to the high surface area of the adsorbent that has better particle retention and adsorption capability toward dissolving contaminants [27].

The AN removal in the sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days is shown in Figure 15(b). Overall, the AN removal in groundwater samples from the sand filter with adsorbent was higher than the sand filter without adsorbent. For the sand filter without adsorbent, the AN removal was -5.71% and 17.14% in tank 1 and tank 2, respectively. The AN removal for sand filter with adsorbent after 1 day was 28.95% in tank 1 and increased to 84.21% in tank 2. After 5 days, the AN removal in tank 1 increased to 69.05%, while AN removal of 95.24% was observed in tank 2. The sand filter with tilapia fish scale macrocomposite adsorbent showed a reduction of concentration below 1.5 mg/L, which meets the requirement for Drinking Water Quality Standards.

Figure 16 depicts the total hardness in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. The initial total hardness of filtered water without the adsorbent was 7.05 mg/L and after the sand filtration process without adsorbent in tank 1, the total hardness rose to 9.23mg/L. Next, the groundwater was flowed into tank 2 for a second sand filtration process, and the total hardness increased to 9.00 mg/L. On the other hand, the initial total hardness of filtered water with an adsorbent for the first day was 8.01mg/L. After the sand filtration process with adsorbents in tank 1, the total hardness rose to 8.48mg/L. Next, the total hardness slightly decreased to 8.29 mg/L after sand filtration in tank 2. After 5 days, the initial total hardness of the groundwater in the tubewell was 7.77 mg/L. The total hardness increased to 8.61 mg/L after the sand filtration process with adsorbents in tank 1. The total hardness then increased slightly to 9.24 mg/L after sand filtration in tank 2. The increase in total hardness might be due to the Ca and Mg content in the adsorbent. The total hardness after the treatment of sand filter with tilapia fish scale macrocomposite adsorbent meets the Drinking Water Quality Standards requirement, which is below 500 mg/L.

Figure 17(a) displays the zinc concentration in the tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days. For the sand filter without adsorbent, the initial zinc concentration was 78.8 μg/L. The zinc concentration decreased to 54.8 μg/L in tank 1 and increased to 119 μg/L in tank 2. For the sand filter with adsorbent, the initial zinc concentration was 130 μg/L and 161 μg/L after 1 day and 5 days, respectively. The zinc concentration decreased to 70.7 μg/L and 33.4 μg/L in tank 1 and tank 2, respectively after 1 day. The zinc concentration decreases from 49 μg/L to 16.9 μg/L after 5 days in tank 1 and tank 2. This shows that the zinc concentration after the treatment of sand filter with tilapia fish scale macrocomposite adsorbent meets the Drinking Water Quality Standards requirement which is below than 3 mg/L. By applying tilapia fish scale macrocomposite adsorbent in tank 1, zinc removal can be obtained from 45-89%.

The manganese concentration in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days is shown in Figure 17(b). For the sand filter without adsorbent, the initial manganese concentration was 78.8 μg/L. The manganese concentration decreased to 54.8 μg/L in tank 1 and increased to 119 μg/L in tank 2. For the sand filter with adsorbent, the initial manganese concentration was 130 μg/L and 161 μg/L after 1 day and 5 days, respectively. The manganese concentration decreased to 70.7 μg/L and 33.4 μg/L in tank 1 and tank 2, respectively after 1 day. The manganese concentration decreases from 49 μg/L to 16.9 μg/L after 5 days in tank 1 and tank 2. This shows that the manganese concentration after the treatment of sand filter with tilapia fish scale macrocomposite adsorbent meets the Drinking Water Quality Standards requirement, which is below 0.1 mg/L. By applying tilapia fish scale macrocomposite adsorbents to the sand filter in tank 1, the manganese removal obtained was from 46-90%. The sorption of heavy metals is linked to the presence of functional groups such as hydroxyl and carboxyl groups on the adsorbent surface, as well as the porous structure and high surface area of the adsorbent [28].

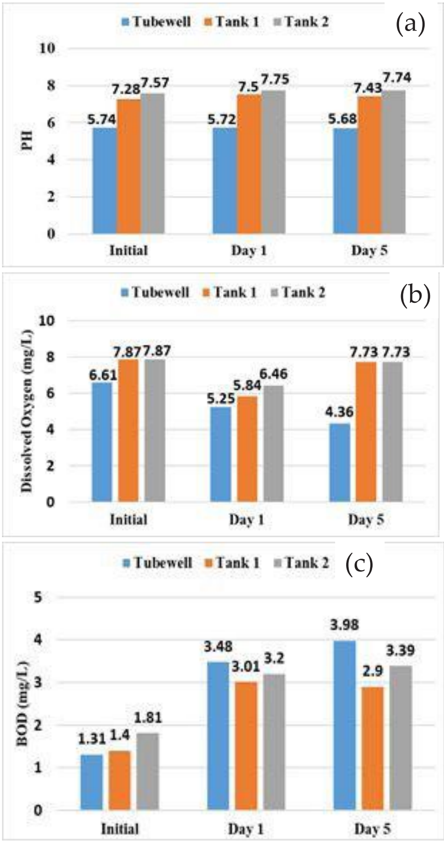
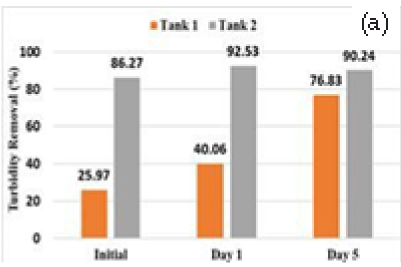


Figure 13: (a) pH, (b) DO concentration and (c) BOD concentration in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days.



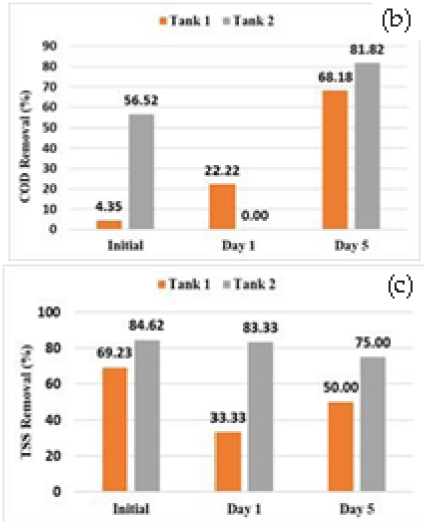


Figure 14: (a) Turbidity, (b) COD, and (c) TSS removal in sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days.

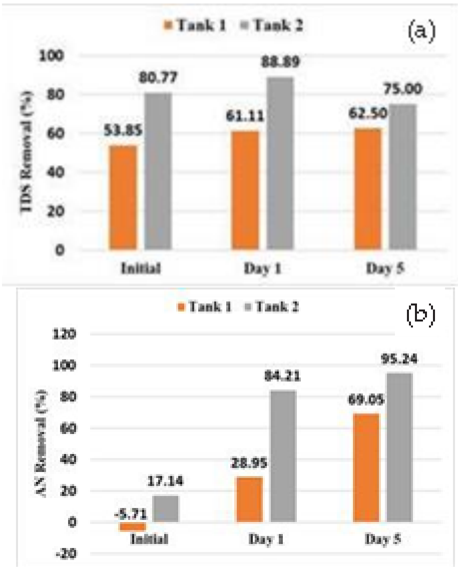


Figure 15: (a) TDS and (b) AN removal in sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days.

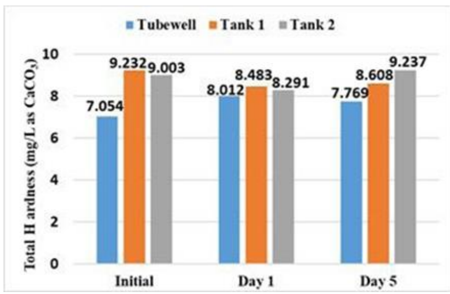


Figure 16: Total hardness in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days.

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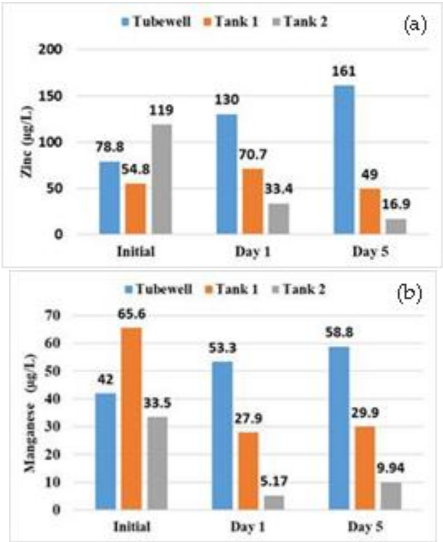

Figure 17: (a) Zinc and (b) manganese concentration in tubewell and sand filter with and without tilapia fish scale macrocomposite adsorbent after 1 day and 5 days.

3. Conclusion

The performance of the sand filter with and without tilapia fish scale macrocomposite adsorbents in a column study showed a pH of 5.84 to 6.23, while the dissolved oxygen (DO) level was 8.75 mg/L to

8.93 mg/L. The highest removal was achieved in the sand filter with tilapia fish scale macrocomposite adsorbent with 16.26% turbidity, 38.89% chemical oxygen demand (COD), 75% total suspended solids (TSS), 32.88% total dissolved solids (TDS), while biochemical oxygen demand (BOD), ammonia nitrogen (AN) and total hardness increased slightly after treatment. The performance of the sand filter with and without tilapia fish scale macrocomposite adsorbent in a real sand filtration system at the site showed a pH of 7.5 to 7.75, while the DO was 5.84 mg/L to 7.73 mg/L. The highest removal was achieved in the sand filter with tilapia fish scale macrocomposite adsorbent with 83.33% turbidity, 81.82% COD, 27.14% biochemical oxygen demand (BOD), 83.33% TSS, 88.89 % TDS, 95.24% ammonia nitrogen (AN), 89.50% zinc (Zn), and 90.30% manganese (Mn). In conclusion, sand filters containing tilapia fish scale macrocomposite adsorbent had higher contaminant removal efficiency for most of the parameters tested compared to sand filters without the adsorbent. The heterogeneous pores and cavities of the tilapia fish scale macrocomposite adsorbent increased the surface area exposed for adsorption. Furthermore, the presence of functional groups such as hydroxyl, alkene, and carbonyl also contribute to the adsorption process. The sand filter with tilapia fish scale macrocomposite adsorbent was able to improve groundwater quality as most parameters were within the permissible limit of Drinking Water Quality Standards.

References

[1] Abbasi-garravand, Elham, Catherine N. Mulligan, and Claude B. Laflamme. 2015. "Using Ultrafiltration and Sand Filters as Two Pretreatment Methods for Improvement of the Osmotic Power (Salinity Gradient Energy) Generation Process." (1570124407):1–12.

[2] Arvanitoyannis, Ioannis S., and Aikaterini Kassaveti. 2008. "Fish Industry Waste: Treatments, Environmental Impacts, Current and Potential Uses." International Journal of Food Science and Technology 43(4):726– 45. doi: 10.1111/j.1365-2621.2006.01513.x.

[3] Baig, Shams Ali, Tiantian Sheng, Yunjun Hu, Xiaoshu Lv, and Xinhua Xu. 2013. "Adsorptive Removal of Arsenic in Saturated Sand Filter Containing Amended Adsorbents." Ecological Engineering 60:345–53. doi: 10.1016/j.ecoleng.2013.09.001.

[4] Bhaumik, Ria, Naba Kumar Mondal, and Soumya Chattoraj. 2017. "An Optimization Study for Defluoridation from Synthetic Fluoride Solution Using Scale of Indian Major Carp Catla (Catla Catla): An Unconventional Biosorbent." Journal of Fluorine Chemistry195:5769.doi:10.1016/j.jfluchem.2017.01.01

[5] Cescon, Anna, and Jia Qian Jiang. 2020. "Filtration Process and Alternative Filter Media Material in Water Treatment." Water (Switzerland) 12(12):1–20. doi: 10.3390/w12123377.

[6] Chai, M. N., and M. I. N. Isa. 2013. "The Oleic Acid Composition Effect on the Carboxymethyl Cellulose Based Biopolymer Electrolyte." Journal of Crystallization Process and Technology 03(01):1–4. doi: 10.4236/jcpt.2013.31001.

[7] Elbana, M., F. Ramírez de Cartagena, and J. Puig-Bargués. 2012. "Effectiveness of Sand Media Filters for Removing Turbidity and Recovering Dissolved Oxygen from a Reclaimed Effluent Used for Micro- Irrigation." Agricultural Water Management 111:27–33. doi: 10.1016/j. agwat.2012.04.010.

[8] Eletta, Omodele, Joshua O. Ighalo, and Omodele A. A Eletta. 2019. "A Review of Fish Scales as a Source of Biosorbent for the Removal of Pollutants from Industrial Effluents Solid Waste Management and Recycling View Project Process Modeling and Biofuels Production View Project A Review of Fish Scales as a Source of Biosor." Journal of Research Information in Civil Engineering 16(1):2479–2510. doi: 10.13140/RG.2.2.20511.61604.

[9] Feng, Yuan, Ji Lai Gong, Guang Ming Zeng, Qiu Ya Niu, Hui Ying Zhang, Cheng Gang Niu, Jiu Hua Deng, and Ming Yan. 2010. "Adsorption of Cd (II) and Zn (II) from Aqueous Solutions Using Magnetic Hydroxyapatite Nanoparticles as Adsorbents." Chemical Engineering Journal 162(2):487–94. doi: 10.1016/j.cej.2010.05.049.

[10] Hagemann, N., J. Harter, and S. Behrens. 2016. Elucidating the Impacts of Biochar Applications on Nitrogen Cycling Microbial Communities. Elsevier Inc.

[11] Janusz, Władysław, and Anna Sedłak. 2011. "Specific Adsorption of Carbonate Ions at the Hematite/ Aqueous

[12] Electrolyte Solution Interface." Physicochemical Problems of Mineral Processing 46(March):65–72. Kaetzl, Korbinian, Manfred Lübken, Edith Nettmann, Stefan Krimmler, and Marc Wichern. 2020."Slow Sand Filtration of Raw Wastewater Using Biochar as an Alternative Filtration Media." Scientific Reports 10(1):1–11. doi: 10.1038/s41598-020-57981-0.

[13] Kaviya, M., P. Ramakrishnan, S. B. Mohamed, R. Ramakrishnan, J. Gimbun, K. M. Veerabadran, M.R. Kuppusamy, K. Kaviyarasu, and T. M. Sridhar. 2019. "Synthesis and Characterization of Nano-Hydroxyapatite/Graphene Oxide Composite Materials for Medical ImplantCoating Applications." Materials Today: Proceedings 36:204–7. doi: 10.1016/j. matpr.2020.02.932.

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[14] Klecker, Christina, and Lakshmi S. Nair. 2017. Matrix Chemistry Controlling Stem Cell Behavior.Elsevier Inc. Leng, Lijian, Qin Xiong, Lihong Yang, Hui Li, Yaoyu Zhou, Weijin Zhang, Shaojian Jiang, Hailong Li, and Huajun Huang. 2021. "An Overview on Engineering the Surface Area and Porosity of Biochar." Science of the Total Environment 763:144204. doi: 10.1016/j.scitotenv.2020.144204.

[15] Li, Peiyue, Xiaodong He, Yi Li, and Gang Xiang. 2019. "Occurrence and Health Implication of Fluoride in Groundwater of Loess Aquifer in the Chinese Loess Plateau: A Case Study of Tongchuan, Northwest China." Exposure and Health 11(2):95–107. doi: 10.1007/s12403- 018-0278-x.

[16] Mao, N. 2016. Nonwoven Fabric Filters. Vol. i. https://doi.org/10.1016/B978-0-08-100575-0.00010- 3.

[17] Masindi, Vhahangwele, and Khathutshelo L. Muedi. 2018. "Environmental Contamination by Heavy Metals." Heavy Metals. doi: 10.5772/intechopen.76082.

[18] Mukherjee, Monobina, and Kurt Schwabe. 2014. "Irrigated Agricultural Adaptation to Water and Climate Variability: The Economic Value of a Water Portfolio." American Journal of Agricultural Economics 97(3):809–32. doi: 10.1093/ajae/aau101.

[19] Navarro-Ruiz, Javier, Damien Cornu, and Núria López. 2018. "Prevalence of Trans-Alkenes in Hydrogenation Processes on Metal Surfaces: A Density Functional Theory Study." Journal of Physical Chemistry C 122(44):25339–48. doi: 10.1021/acs.jpcc.8b06880.

[20] Salmasi, Farzin, John Abraham, and Arian Salmasi. 2021. "Effect of Stepped Spillways on Increasing Dissolved Oxygen in Water, an Experimental Study." Journal of Environmental Management 299(August):113600.doi:10.1016/j.jenvman.2021.113600.

[21] Shanura Fernando, I. P., K. K. Asanka Sanjeewa, Kalpa W. Samarakoon, Won Woo Lee, Hyun Soo Kim, Eun A. Kim, U. K. Gunasekara, D. T. U. Abeytunga, Chandrika Nanayakkara, E. D. De Silva, Hyi Seung Lee, and You Jin Jeon. 2017. "FTIR Characterization and Antioxidant Activity of Water Soluble Crude Polysaccharides of Sri Lankan Marine Algae." Algae 32(1):75–86. doi: 10.4490/algae.2017.32.12.1.

[22] Shiqun, Li, Ren Shuxia, Liu Biao, and Hu Jiashan. 2006. "Powdered Fish Scale Strengthening In Novel HAP–M–PALC Composite Cement." Materials Research Innovations 10(3):299–304. doi: 10.1179/mri.2006.10.3.299.

[23] Sosthene, Kiemde Maximilien, and Narcisse Gahi. 2018. "Low Cost Filtration of Domestic Wastewater for Irrigation Purpose." World Journal of Engineering and Technology 06(03):585–602. doi: 10.4236/wjet.2018.63036.

[24] Villanueva-Espinosa, J. F., M. Hernández-Esparza, and F. A. Ruiz-Treviño. 2001. "Adsorptive Properties of Fish Scales of Oreochromis Niloticus (Mojarra Tilapia) for Metallic Ion Removal from Waste Water." Industrial and Engineering Chemistry Research 40(16):3563–69. doi: 10.1021/ie000884v.

[25] Wasewar, Kailas L., Surinder Singh, and Sushil Kumar Kansal. 2020. Process Intensification of Treatment of Inorganic Water Pollutants. INC.

[26] Xu, Chao, Wenhao Yu, Kexin Zheng, and Chen Ling. 2020. "Novel Composite Oxygen-Containing Resins with Effective Adsorption towards Anilines : Physical & Chemical Adsorption." (March). doi: 10.1002/jctb.6405.

[27] Zainol, I., N. H. Adenan, N. A. Rahim, and C. N. Aiza Jaafar. 2019. Extraction of Natural Hydroxyapatite from Tilapia Fish Scales Using Alkaline Treatment. Vol. 16. Elsevier Ltd.