Use of Agricultural Wastes and Limestone for the Removal of Iron from Drinking Water

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Abstract - **In this study, adsorption method was employed in the treatment of iron in drinking water. Groundwater samples were obtained from Ota environs and tested for Iron impurity using Plainest 8000 photometer. Adsorbents such as rice husk, plantain peel, and limestone were used in the treatment of the water samples. All three adsorbents were washed with distilled water and oven dried at 100ºC for 24 hours. The dried plantain peel was ground to powder using pestle. Both the rice husk and limestone occurred naturally in granular states. The density of rice husk, plantain peel and limestone were found to be 0.332 kg/l, 0.6 kg/l and 2.614 kg/l respectively. Subsequently, all three materials were heated to 200ºC in an oven for 6 hours. They were, thereafter, sieved using 425 MIC sieve. Batched experiments on the efficiency of iron removal were conducted by measuring 10 ml of each adsorbent and adding it to 100 ml of water samples in turn. The mixture was stirred using a magnetic stirrer and the contact time during stirring was varied for 5, 10, 15 and 20 minutes in order to compare treatment efficiency. Results indicate that all three materials removed iron from the water samples. However, only limestone showed a consistent reduction in iron concentration with respect to time while the agricultural wastes (rice husk and plantain peel) had fluctuations in iron concentration with respect to time. Limestone, rice husk and plantain peel had ultimate removal efficiencies of 56.7%, 79% and 83.3% at 20, 20 and 15 minutes respectively. Further experiments were recommended in other to determine optimum iron removal conditions.**

Keywords: water treatment, adsorption, adsorbent, iron, drinking water.

I. INTRODUCTION

Heavy metal contamination of water is a global problem that has been a subject of research for decades [1-4]. While metal contamination in water may occur naturally, evidence abounds that anthropogenic causes are more widespread [5]. These anthropogenic causes include pesticide and fungicide applications in agriculture, metallurgical industries, battery manufacture, paint manufacture, mining activities etc [6]. The adverse effects of high concentrations of heavy metals on public health is devastating, especially in children [7]. Common adverse health effects of metals include breakdown of vital organs such as kidneys, liver and cerebral system [1, 8]. Specifically, iron is a metal that is useful in the human body [8]. Iron is a common element found in lateritic soils [4] and lateritic soil features commonly in Ota. Excessive iron metal in water, however, leads to problems such as stained teeth, brown colour stained toilet wares (Figure 1) and formation of free radicals in the human body [8]. Several methods of heavy metal removal from water or wastewater such as precipitation, electroplating, chemical coagulation, ion-exchange, membrane separation, and electrokinetics have been used successfully in the past [6, 9]. However, adsorption method was consistently found to be economical and suitable for developing countries because of its treatment and cost efficiency [6]. In the current study, locally available materials such as rice husk, plantain peel and limestone were used to treat iron contaminant in water. While rice husk and plantain peels are agricultural wastes, limestone, on the other hand is a soil material that is commonly found in many parts of Nigeria. The three materials were used with the aim of determining their rate of removal of iron.

II. METHOD AND MATERIALS

A. *Study Area*

This study was conducted in Ota, Ogun State Nigeria. Drinking water samples were obtained from borehole sources located in Iyana Iyesi, Bells University and Covenant University, all in Ota, Ogun State.

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Fig. 1: Iron stained wash hand basin in a covenant university residence

All borehole water samples were subsequently mixed together in equal ratios to obtain a single sample of drinking water. The Rice husk was obtained from a rice mill at Sihun village near Owode-Egba, Ofada, Ogun State. The plantain peels were collected from a plantain chips factory at Ketu, Lagos while crushed limestone was bought from Adenuga feeds, Sabo market, Ikorodu, Lagos.

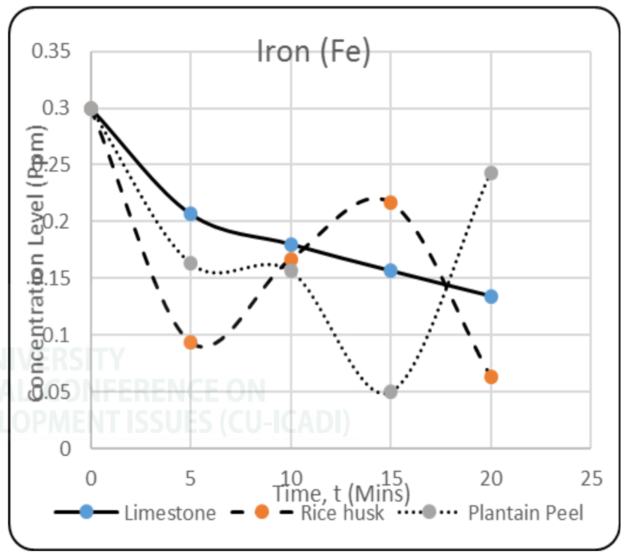
B. *Experimental Procedure*

The three adsorbents (rice husk, plantain peel and limestone) were washed with distilled water and oven-dried at 100°C for 24 hours. The plantain peels were grounded using a milling machine, as the other two materials were already in powdered form. Each of the adsorptive materials was weighed and the density of rice husk, banana peel and limestone were found to be 0.332 kg/l, 0.6 kg/l and 2.614 kg/l respectively. The three materials were carbonized in the Model SDO/225 oven at 200°C temperature for 2 hours. After removing them from the oven, they were sieved with 425 MIC sieve but the plantain peel was pounded before sieving due to its adhesive state, which caused the granules to pack together in balls. Subsequently, equal volumes of each adsorptive material (10 ml) was applied to the water samples (500 ml) and stirred using an electronic stirrer under room temperature (27.4°C) for varying durations (5 mins, 10 mins, 15 mins, and 20 mins). Each sample was allowed to settle for 30 mins before sieving out the adsorptive material with sieve 45 MIC. The obtained treated water was then poured into plastic bottles. The samples were left undisturbed for 48 hours to allow further settling. Thereafter, the water samples were filtered again and taken for metal analysis using Plainest 8000 photometer.

III. RESULTS AND DISCUSSION

As shown in Figure 2, the initial concentration level of iron in the raw water sample was 0.3 mg/l. The iron concentration level, however, reduced consistently following contact with limestone at stirring time of 5, 10, 15 and 20 minutes to 0.206, 0.18, 0.157 and 0.134 mg/l respectively. This translates to 56.7% rate of removal of iron from the water sample. Similarly, following the same procedure as limestone, rice husk had a 79% rate of removal of iron (Fig. 2). Finally, plantain peel reduced iron concentration to 0.05 mg/l (83.3%) at optimum treatment time of 15 minutes. The Standards Organization of Nigeria [10] recommended maximum contaminant limit for Iron in drinking water is 0.3 mg/l. Although the mean value of iron in the raw water sample is 0.3 mg/l, all three adsorbents were able to further reduce iron contaminant from the water samples at different rates.

Fig.2: plot of iron concentration level and time of treatment using rice husk, plantain peel and limestone



With a removal rate of 83.3%, plantain peel gave the highest treatment efficiency. However, the plantain peel treated water was aesthetically unattractive as the treated water sample had a dark coloration (even after 48 hours settling time) (Fig. 3). This phenomenon is probably caused by the leaching of soluble organic compounds into the water sample as observed by Nguyen, Ngo, Guo, Zhang, Liang, Yue, Li, and Nguyen [11].

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Fig. 3: samples of water treated with plantain peel

Rice husk and Limestone which had removal rates of 79% and 56.7% respectively, however, had clearer water samples after treatment (Fig. 4).

IV. CONCLUSION

This research has shown that iron contaminant can be removed from drinking water samples using rice husk, plantain peel and limestone, with plantain peel showing the highest iron removal rate. However, due to the dissolution of organic compounds in plantain peel into the water, which gave the treated water sample a dark colouration, it is recommended that chemical pre-treatment should be given to plantain peel in future experiments to prevent unpleasant coloration after treatment (Nguyen et al., 2013). Also, further experimental studies detailing optimum treatment conditions such as temperature, stirring speed, adsorbent surface morphology and desorption studies of the adsorptive materials should be embarked upon. This solution has the potential to provide sustainable and economical heavy metal removal from water to people living in developing countries. In addition, rice husks and plantain peel which are agricultural wastes under normal conditions could now find usefulness as raw materials for the treatment of metals in drinking water.

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