Comparative Study of Iron Removal from Borehole Water Using Water lettuce and Coconut husks

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Abstract

Iron is a common impurity in water, often ignored, except few inhabitants who recognize its presence in water having numerous pessimistic implications against Community Health problem. Its presence causes unpleasant taste in water and affects its odor as well. When used on a daily basis, it stains fixtures and laundries. The removal of iron is essential and imperative for universal treatment step. The ultimate goal of this finding encamp round the use of traditional method of iron removal of borehole water by using coconut husks and water lettuce cum their ashes. They are regularly accessible agricultural farm produce or by-products adsorbents used for iron removal. The coconut husks charcoal has been proven to be an ideal adsorbent of borehole water iron removal potentials for drinking water with an optimal concentration set up of 500ppm. The most favorable conducive timeframe for efficient iron removal in water peg at 4hrs. MnO2 incorporated coconut husks charcoal and were very effective to remove the iron content in water below 0.3-0.4 ppm without increasing the pH. Water lettuce ashes mix with Coconut husks charcoal in addition proved to be an excellent iron removal adsorbent. The production of Coconut husks and Water lettuce ash proved to be extremely cost cheaper, just requiring burning only its parts in a muffle furnace at a regulation of 500 degree Celsius for about 4hrs. These techniques of iron removal were mainly for household utilization.

Keywords: *Borehole water, Comparative study, Coconut husks, Iron, Water lettuce*

Introduction

1.1 Background of the Study

Potable drinking water is a prerequisite of life. Meanwhile, minute quantity can sustain human life, needless of arguing about its overall usefulness for bathing, cooking, drinking, washing, cleaning and other sanitary purposes (Anderson & Johansson 2002., Hem 1985). Most of the water used in

Bayelsa State for domestic, commercial or industrial activities comes from the ground, lake, rain, river, spring and sea water. Typical surface water supplies are void of iron (Edori et al., 2021., Tyrrel et al., 1998). Groundwater (commonly called borehole water) is the main source of potable drinking water here, otherwise used for domestic activities by rural and urban dwellers within the state which contains huge shucks of iron in excess of 0.3 mg/L (Joseph, 2011 & Al-Qaisi et al., 2022). The most common source of water in the rural communities is river or creek water which is readily contaminated with various types of anthropogenic pathogens activities or oil spills (Aishwarya et al., 2018). Whereas, the number of people lacking access to potable drinking water has drop from 1.1 billion in 2000 to 703 millions in 2022 according to World Water Day observations on March, 2022.

Urbanization and rapid industrialization quest is the major proponent for increased borehole water drilling to quench humans, animals and plants tastes for quality water. The urge for potable drinking water cannot be overemphasize both for drinking, irrigation, municipal, fiber needs, plants growing, industrial use/navigations, recreation and power generation (Beenakumari et al., 2009., Huda 1995). The accessibility of potable drinking water had greatly improved over the years in most developed Countries of the World such as Chile, Canada, Denmark, Singapore, Sweden, Austria, Iceland Germany, Greenland and Switzerland. But back here in Nigeria, most especially in Bayelsa State in particular, potable drinking water is still a mirage, for instance were aboki popularly called meruwa are the major distributors of borehole waters at each given point within the state capital, not to mention the ordeal face by the rural populace endlessly. A worst case scenario is when natives of most communities within the Niger Delta Region defecate, bathe and drinks from the same water source, thereafter causing an outbreak of waterborne diseases, such as cholera, dengue fever, dracunculiasis, hepatitis and typhoid Thresh et al., (1958). In Nigeria about 78 millions children are at risk of convergence three water related threats due to inadequate water, sanitation cum hygiene related diseases and climate hazard according to a new UNICEF analysis. Thus, one-third of Nigeria children do not have access to basic water at homes, while two-third of them does not have basic water sanitary service. Poor hand hygiene mentality is limited by three-quarters of the children, which are unable to wash their hands due to lack of water and soap in their homes, as a result of this Nigeria is rank one of the countries that carry the heaviest burden of child deaths from diseases cause by inadequate water treatments due to poor hand wash, such as diarrheal diseases. Nigeria currently ranks second out of 163 countries of the world with the highest risk of exposure to climate and environmental threats. Groundwater levels are also dropping requiring some communities to dig wells twice as deep as just decade ago. At the same time rainfall has become more erratic and intense, leading to floods that contaminates scarce water supplies. Invariably there is a sharp demarcation between access to potable drinking water and gross domestic product per capita on the contrary some researchers are of the view that by 2025 many more, if not more than half of the World populations will plug into water-based vulnerability (Edori et al., 2021). This implies that by 2030 even some developing regions of the World will be in dire need of over 50% water supply (Vanitha & Rajan, 2018). The ever abundance presence of iron makes up 62,000ppm or 6.2% by weight of the earth crust which has a yellow metallic appearance called 'fool's gold' due to it mistaken identity for gold, sighted in almost every borehole water drilled in the nuke and cranny of Bayelsa State. This is disquieting and required urgent preventive method to ameliorate this ugly trend that has become public outcries (Kapulu 2013 and Pontius

1990). Iron ores is a common feature of groundwater supply chain which gives discoloration, terrible taste, staining and deposition in the distribution of water causing high turbidity (Sharma, 2001). When water percolates through the ground strata it dissolves the iron from the iron ore deposits as ferrous bicarbonate $C_2H_2FeO_6$, also known as clear water iron. Iron (Fe) basically would revert back to its natural state as iron ore (Das et al., 2007, Malay et al., 2008). Iron if present in a solution can be easily sighted as precipitates in a solid like particle of ferric hydroxide $Fe(OH_3)$ oftentimes called red iron water. The bacterial found in iron ores are a group of smaller organisms that change ferrous iron into it ferric state through metabolic reactions. This metals cause corrosion by attacking steel pipes thereafter producing iron. Whereas, a gigantic amount of these elements form a gelatinous mass that in turn attacks ferric hydroxides which clog to pipes as well as plumbing fixtures thereby reducing the flow rate (Colvin et al., 2011). The permitted limit for potable drinking water that is without charge from Ironic pollution is given as 0.3 mg/L by WHO. Comparatively, several method have been put in place for the efficient removal of metallic contaminants, yet the progression are most unlikely not being used due to it none acceptability, high efficiency, reproducibility and economical values (Patel, 2019).

Effects of iron infested water

Low levels of iron found in drinking water are not usually dangerous and does not have an adverse brunt humans health. Iron is regarded as a secondary contaminant (EPA). Being secondary contaminants with aesthetic and cosmetic consequences, like foul tastes and stains, does not makes it dangerous to consume. Iron itself is essential for a healthy, balanced diet and contributes to red blood cell production and transports oxygen throughout the body. Spinach, eggs, lentils, and shrimp are all iron-rich foods that provide our body with this vital mineral. But at a higher concentration, iron seems to be toxicity. Hemochromatosis is an inherited medical condition that prevents one intestine from properly absorbing iron. Hemochromatosis can lead to lethargy, weight loss and confusion, and cirrhosis of the liver. Conversely, hemochromatosis is a hereditary state, and drinking borehole water with elevated iron concentrations may not result into a disorder. Because records have it that an average Americans drink more than 1 million glasses of water per day, Environmental Protection Agency (EPA). Thus, adults consume more water than before due to rising heat waves globally. Statistics made available by the United States Geological Society (USGS) state that water composes about 60% of our bodies ensuring proffer functioning of our bodies basic molecular life, encompassing our DNA, cell membranes, proteins and works. Although, over 780 million people globally lack access to potable drinking water, Centers for Disease Control and Prevention (CDC). Water lettuce and coconut husk could be of economical Importance to humans when proven to be of immense benefit in iron removal both in commercial and personal used, owning to It availability, relatively inexpensive and potential substitute absorbents. Water lettuce has numerous medicinal applications. They are diuretic and are used for treating some forms of venereal disease, hemorrhoids and dysentery. It also helps to heal tubercular lesions in lungs. The plant is used as an infusion or a decoction, is macerated or dried, etc. The Tikunas, an Amazonian tribe, crush the leaves with salt and apply the mixture as a wart remover. The plant may shelter mosquitoes that transmit malaria and encephalitis. While Coconut husks have the potential health benefits owing to their antimicrobial activities and high fiber content, their husks contain bioactive ingredients which demonstrate inhibitory effects against numerous

bacteria such as, common cariogenic bacteria found in the oral cavity. The antimicrobial activity of coconut husk extracts has been known to be concentration-dependent and more valuable against gram-negative organisms. Furthermore, coconut husks are rich in fiber, lignin, cellulose and additional minerals, making them suitable for various applications, including as a foundation material for structures. The fiber in coconut husks has been evaluated for its weight capacity potential, indicating its favorable use in supporting and holding houses. Besides that, coconut husks have been studied for their prospective use as biofertilizers, as they contain phosphate solubilizing bacteria that can enhance plant growth and productivity. In conglomeration, coconut husks offer a variety of potential health benefits, including antimicrobial properties and fiber-rich composition. Recalling Shahad et al., 2022 studied iron removal from groundwater using alternate sources of low cost materials such as Sawdust, rice husk and lime stone as a new method of iron removal. Equally Familusi et al. (2018) analyzed the effectiveness of sawdust adsorbent in removing raw water contaminants (Ho et al., (2017) and Balaji et al., 2014). Fallah et al., (2021), experimented the viability of sawdust as a potential adsorbent cum its adsorption system designed for TOC (Fallah et al., 2021). The bases of this research were to appraise the effectiveness of this filtration method using low cost materials like water lettuce and coconut husks in removal of iron from borehole water. At the tail end, the goals of using low cost natural adsorbent in adsorbing iron from contaminated borehole water around Yenagoa Metropolis is achieved. The filtration method was seamlessly carried out at diverse magnitude of water lettuce and coconut husks.

Materials and methods

Study area

Bayelsa State has eight (8) LGAs, it extends between latitude 4^0 15’ and 5^0 23’ N and longitude 5^0 15’ and 6^0 45’ E. Bayelsa State is located in the South-South Region of Nigeria, being the only homogeneous Ijaw speaking State bounded to the North by Delta state, to the East by Rivers State and to the South and West by the Atlantic Ocean. The state capital occupies a landmass of about 21,100 Km2. A swampy, mangrove and tropical rain forest, it is the traditional home for the Ijaw peoples, a renowned fishing group, major exporters of palm oil and kernels, high Agricultural outputs and heavy exploitation of petroleum and Natural gas in large deposits. Who are prone to several health diseases and poverty (The daily times, 2022). The over burden presence of Iron seen in Bayelsa State was the sole reason for conducting this research across the length and breathe of Bayelsa.

Fig. 1. Map of the Study Area

Fig. 2. Glimpse of iron infested Borehole water

Fig. 3. Iron Ores

Fig. 4. Water Lettuce

Fig. 5. Sand

Fig. 6. Coconut Husks

Fig. 7. Limestone

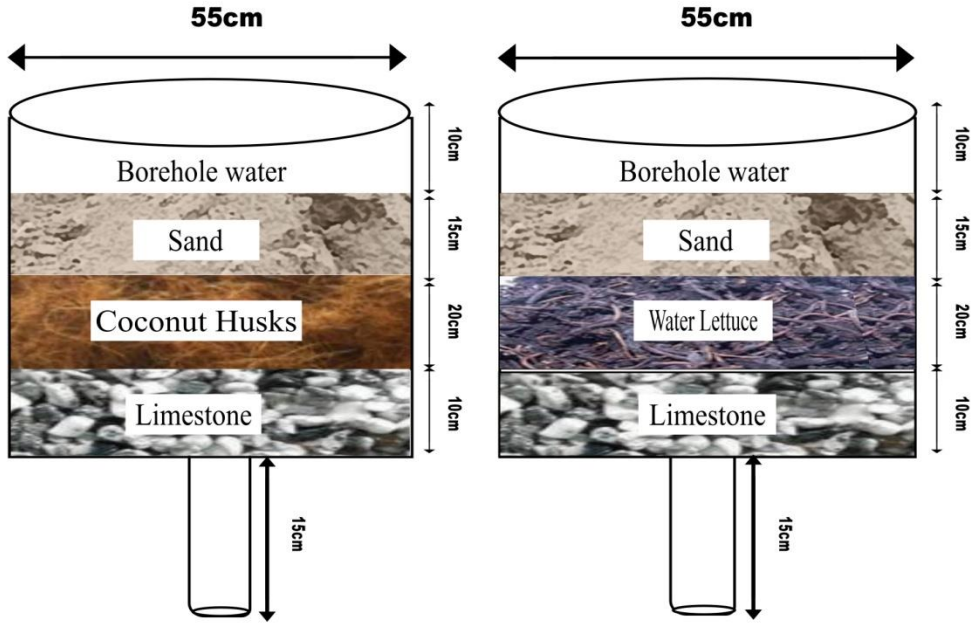

Fig. 8. Experimental set up of filtration medium

Preparation of iron solutions

Iron pyrite habitually known as Fool's Gold due to its resemblance to gold, often occurs in quartz veins. Pyrite is an important source of sulfur dioxide that is primarily used to produce sulfuric acid, a veritable industrial acid and a rhombic crystalline salt that is soluble in water at room temperature. A liter of iron solutions was prepared at diverse concentrations of iron (15, 25, 35, 45, 55, 65, 75 and 85) mg/L.

Preparation of the filtration device

Preparation of limestone; Lime stones is a veritable key component of raw materials used for producing building materials such as cements. The stones used for this research were bought at the market and amassed hand broken sieved. The amassed hang on to in16 mm sieve and percolate in 20 mm sieve are taken and they are washed and oven dried at 60 degree for one hour as shown.

Preparation of water lettuce and coconut husks

Water lettuce and Coconut husks was mash and sieved in 1.19 mm sieve and rinse with water until the color of washed water was pure. Thereafter, they were sun-dried for 3 days, oven dried at 115 ℃ for 3 hours to get rid of unnecessary moisture, and then they were used as filtration medium.

Setting up the filter

The filter was design with a height of 55 cm glass with a pore of (3 × 3 cm). The exit was fixed to the filter at one edge. The films of filtration medium were laid using sand, lime stone aggregates, coconut husks and water lettuce. The sand stratum was laid on the top for 15 cm; thus, the subsequent stratum was aggregates of limestone laid for 10 cm. The central stratum was laid between 20 cm using coconut husks and water lettuce at diverse extent. Thus, the upper stratum was lined with aggregates of limestone laid between 10 cm. Limestone and sand stratum was engaged for an effortless and standardized water circulation throughout the filtration medium.

Filtration process

The method of filtration was conducted at a stack up of 3 m3/m2·hr. diverse magnitude of filtration medium were engaged (Coconut husk, coconut husk/water lettuce ratios of (1:1, 0.5:1, 1:0.5), and water lettuce) to evaluate the proportion decrease of iron concentration by engaging only coconut husk, water lettuce and mixed coconut husk and water lettuce at dissimilar magnitude as filtration medium. This method was employed at a steady temperature and pH of 7. The waste matter was composed at the end of each experimental section. The composed waste matter was analyzed using Atomic Absorption Spectrometer for iron concentrations.

Table1.1 Groundwater as a share of drinking water by Continents

Continents	**Share of drinking water from groundwater (%)**	**People served (millions)**
Asia Pacific	32	1000 to 1200
Europe	75	200 to 500
LatinAmerica	29	150
UnitedStates	51	135
Australia	15	3
World		1500 to 2000

Source: Sampat P (2000)

Table 2.1 Statistics of Top 10 Countries with the cleanest water in the World

Names of Countries	**Purity Level/Intake**	**Locations**
Chile	Instant	Puerto
Canada	Direct	Springwater near Toronto
Denmark	Instant	Copenhagen
Singapore	Direct	Singapore
Sweden	Direct from lakes	Stockholm
Austria	Instant	Austria
Iceland	Straight from lakes	Iceland
Germany	Direct	Germany
Greenland	Processed	Greenland
Switzerland	Direct from Strand	Switzerland

Source: ISO/TC 224 & 147

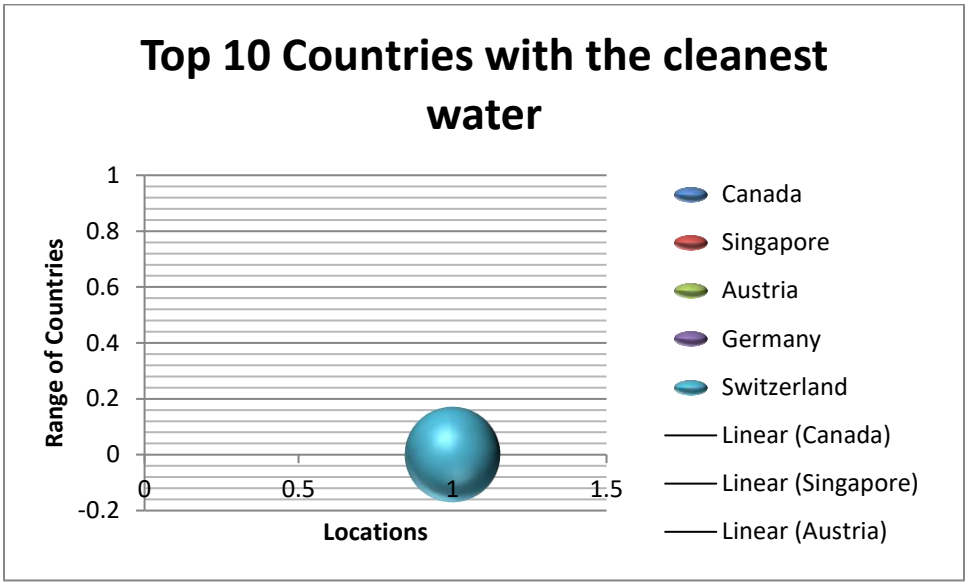

Fig. 9. Top 10 Countries with the cleanest water

RESULTS AND DISCUSSION

Consequence of preliminary iron concentration, Dissimilarity of preliminary concentrations (15, 25, 35, 45, 55, 65, 75 and 85) mg/L were analyzed, as revealed in Figure 5 and the percentage elimination of iron maybe resolved using this formula:

$$\text{Percentage elimination} = \frac{Ci - Cf}{Ci} \times 100 \quad (1)$$

Where: Ci – iron preliminary concentration, mg/L; Cf –iron final concentration, mg/L. The analysis was carried out at a steady temperature and pH of (6.5–7). The imagery above x-rayed the local materials used as potentials iron removal at a performance index of 95.77–97.02% at 85mg/L preliminary iron concentration. The most efficient magnitude of iron adsorption observed so far at an elevated concentration of iron was studied by Aniket et al., (2017) and Hoffman et al., (2006).

Effect of adsorbent

Consequences of the adsorbent dosage (combination ratios) on iron removal potentials using coconut husks and water lettuce was analyzed for both iron concentration as x-rayed in Figure 3 & 4. The maximum removal efficiency was observed at mixture of 0.5:1. More so, the materials i.e. coconut husks and water lettuce, can individually eliminate iron to a certain extent, but when mixed at the ratio of 0.5:1 (water lettuce: coconut husks) their removal potentials astronomically enhance. These farm produce are readily available at a cheaper and more affordable rate. Thus, this method could be easily replicated by the end users in areas where there are heavy presence of iron in their drilled borehole water as filtration medium for household consumption.

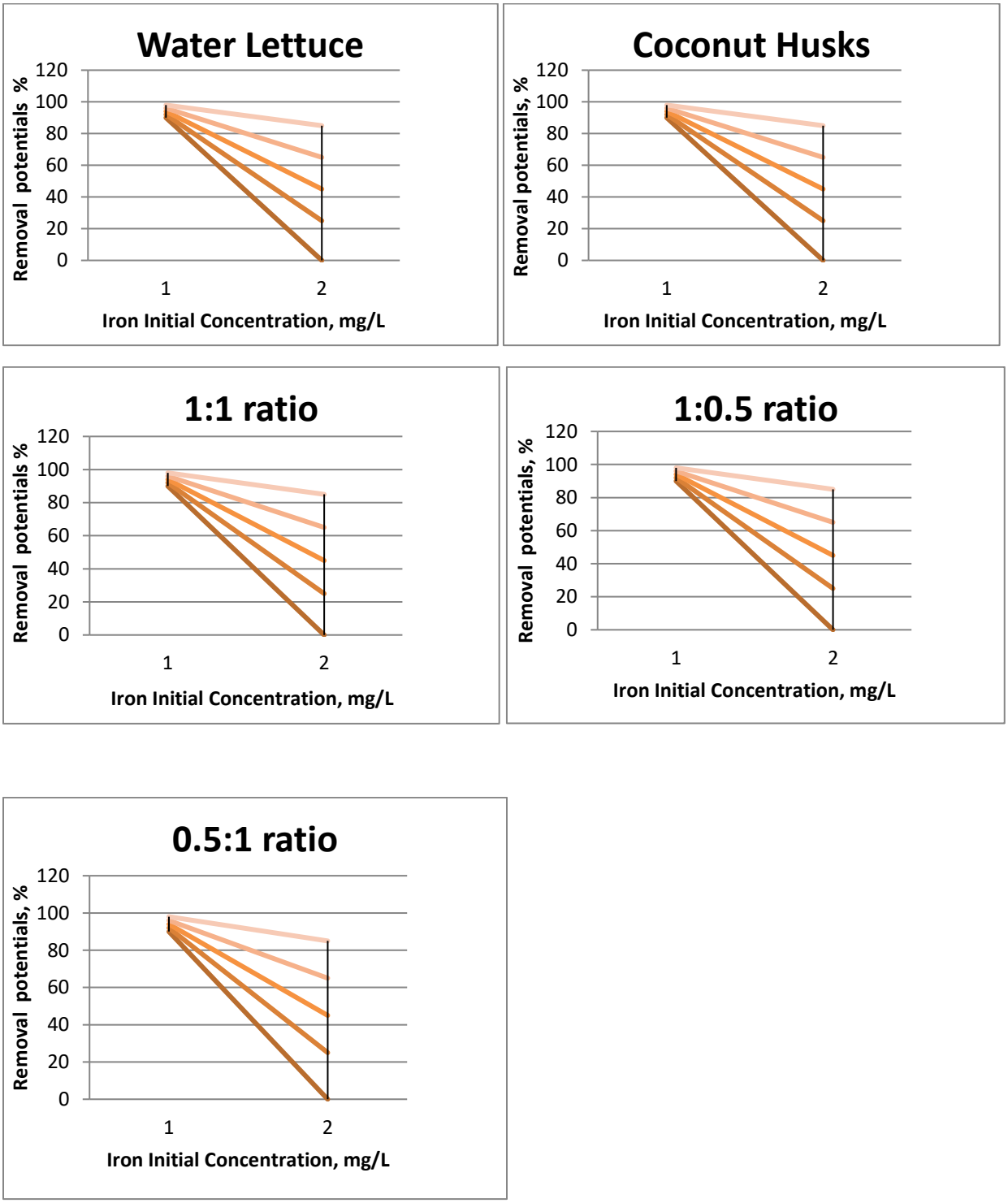

Fig. 10. Percentage Removal of iron ores

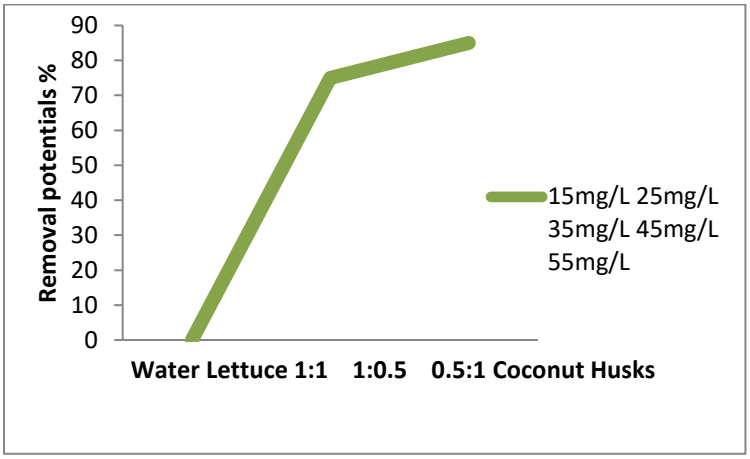

Fig. 11. Adsorbent dose effect on borehole water iron removal potentials

Effect of pH

The consequences of pH were analyzed between 2 to10 and the observed values were shown in the Figure 7. The preliminary concentration of iron was 85 mg/L at a combine ratio of 0.5:1 (water lettuce: coconut husks). The analyzed results showed that pH had an overwhelming influence on iron removal potentials of water. The side by side percentage increment with pH of 2 - 6.5 and subsequent fall of pH from 6.5 -10 was as a result of it basify. Meanwhile, at low pH values, water lettuce and coconut husks demonstrate awfully low trend of iron removal potentials of positively charge particle H+ (proton) with metal ions for binding sites (Megha et al., 2019). Water lettuce and coconut husks demonstrate the highest quantity of iron removal potentials with a pH 6.5.

CONCLUSIONS

The most suitable iron removal potentials were noticeable when water lettuce and coconut husks absorbent were combinable used as a medium of filtration for borehole water iron removal in a high concentration of iron dominance. The obtained results were efficaciously achieved at 87-93.06% yield for each filtration medium. The potential efficacies were highly noticeable between 93.06% range of water lettuce and coconut husks of 0.5;1 with a dimension of 85 mg/L. The peak of adsorption was evidential at a higher dimension of iron ores. Water lettuce and Coconut husks portrayed acceptable qualities as a medium for removing turbidity (Zahur-Uz-Zaman et al., 2023). pH with even a lower measurement of water lettuce and coconut husks showcase a premium removal potentials of iron ores from boreholes water source. Although both water lettuce and coconut husks had no negative influence on the pH of borehole water.

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