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Application of Natural Coagulant for Removal of Heavy Metals from Wastewater

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Abstract

Wastewater contamination is majorly contributed by commercial or domestic means, which include sewerage disposal and large-scale industries such as mining and manufacturing industries. Wastewater is a huge problem in most of developing countries and all across the world, the most prone areas to heavy metal contaminations are mainly Asia and South America. The *Moringa* seed cake is an effective natural coagulant of heavy metal remover, it has an innate capability to remove physical and chemical contaminants of water, such as pH, and EC, besides it is cheap source in water treatment. This work was carried out to confirm the impact of powder extracted from mature and dried *Moringa Oleifera* Press Cake (MOPC) on water quality. A successful reduction in the concentration of heavy metal after MOPC treatment was noted. The removal of chromium and cadmium (2 mg/L) was noted as 92.85% and 89.84%, for (4 mg/L) chromium and cadmium were 82.30% and 81.23%, whereas for (6 mg/L) chromium and cadmium it was noted as 81.53% and 79.52%. The turbidity of the wastewater is 47.7 NTU, which was reduced to a minimum of 9.7 NTU after adding MOPC in a MOPC solution with an optimal of 20,000 ppm. After being treated with various concentrations of MOPC, the pH fluctuated in between (8.13 and 7.13), and there was no statistically significant difference. When in an optimal concentration of 15000 ppm, a decrement in COD of wastewater from (236.3 mg/L to 98.03 mg/L) was observed.

Keywords

Wastewater Treatment; Heavy Metals; Turbidity.

1. Introduction

The untreated disposal of contaminated water increases the water pollution levels in water reservoirs [1]. Today, water contamination is that at an unprecedented rate, mainly due to waste produced by anthropogenic activities, including domestic, industrial and agricultural waste, which is discharged directly into the water bodies [2]. And in recent years, the emphasis on reducing waste and conserving water has also paved the way for the processing of concentrated or toxic residues [3]. It has been found that none of the approaches have yet been implemented individually in the wake of applications for wastewater treatment with good economy and higher energy capacity [4]. Continued population development and industrialization also culminated in the loss of diverse ecosystems based on human

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activity [5]. The unregulated release of heavy metals into the environment has presented a big problem worldwide due to industrialisation and urbanization [6].

Because of their toxicity, the presence of heavy metal ions is a major problem for many life types. Heavy metals are not biodegradable and tend to develop in living organisms which trigger various diseases and disorders [7]. Most of the elements are extremely water-soluble, well-known carcinogenic and toxic agents. Heavy metals are considered the following elements: copper, silver, zinc, cadmium, gold, mercury, lead, chromium, iron, nickel, tin, arsenic, selenium, molybdenum, cobalt, manganese and aluminum [8]. Several approaches have been proposed and studied to eliminate dangerous heavy metals from water supplies. Although chemical precipitation, coagulation, ion exchange, solvent extraction, filtration, evaporation and membrane approaches have been implemented for the same reason, most procedures have some drawbacks, such as the need for multiple pre-treatments and external therapies [9]. The need for secure and cost-effective methods to remove heavy metals from wastewater needs work into low-cost agricultural waste by-products such as cane bagasse [10], coconut husk [11], oil palm shell [12], and *Moringa Oleifera* pod [13].

Moringa is a family of ontogenetic shrubs and trees, and has 13 species in the Moringa genus. Moringaceace is first discovered in India and Asia, then naturalized in tropical and subtropical Africa [14]. There are three types of Moringa; slender plants, bottle plants, shrubs and herbs. The bottle trees are Moringa the ovalifolia, Moringa the hilderbrandtii and Moringa the drouhardii. The group of slender trees is further classified into three groups, Moringa concanensis, Moringa peregrina and Moringa oleifera, among others. These are found primarily in Arabia, the Red Sea and the Indian subcontinent.

Moringa oleifera seeds have acquired special importance for all the plants used in water purification owing to their ability to treat water by acting as both a coagulant and antimicrobial agent. Research has been under way to determine Moringa oleifera's performance in water treatment since the early 1970s [15]. The antimicrobial and non-toxic properties of Moringa oleifera seeds have been observed in many studies [16]. Acid mine drainage occurs in South Africa due to the contamination of groundwater from mining operations, making groundwater unfit for use and eventually requiring treatment of the quality of human consumption by various methods.

Moringa oleifera pod, a low-cost agricultural waste was used to manufacture activated carbon used in the treatment of chromium ion in wastewater effluent from the tannery section of the Nigerian Leather and Science Technology Institute (NILEST), Samaru, Zaria, Kaduna State, Nigeria reported by [17]. It evaluated the influence of time and temperature on the quality of treatment and the impact of agitation on the quality of treatment obtained with the activated carbon generated. The activated carbon demonstrated a significant capacity to remove chromium ions from wastewater tannery samples.

2. Experimental measurements

Leaves and seeds of *Moringa Oleifera* are often widely used in water treatment, since they have no major side effects and are both biodegradable and non-toxic [18]. Moringa Oleifera is a tropical tree that with its many applications is immune to drought. It is recognized as an significant source of vital food elements and is also well known for its rich oil content (30–40 percent weight yield) [19]. The study described here aims to investigate Moringa seed pod (MSP) and Morula nut shells (MNS) as a bio-remedial solution to metal recovery from wastewater and borehole water (copper, zinc, gold, manganese, cadmium, magnesium, and iron) [20]. The aim of this research is to develop an inexpensive and effective metal ion adsorbent from abundant natural waste sources, such as leaves of Calotropis, and to explain the adsorption mechanisms [21].

The wastewater used for the experiment was obtained from Southwest University of science and technology Mianyang, China. While the Moringa Oleifera Press cake (MOPC), used in the experiment, was harvested from the local market of Mianyang, China. After mechanical pressing, it was soaked in fresh water for 24 hours to remove some remaining oil to use the MOPC. The MOPC

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was then filtered down and inserted into the chiller at 4 °C. The MO solution was prepared to render MO solution of 25,000-ppm by inserting 10 g (dry base mass) of MO in 500 mL of distilled water. Stirred the solution and the purified water would absorb the MO. The solvent was diluted to 10 mL to 1,000 ppm; 5,000; 10,000; 15,000; 20,000 and 25,000 ppm.

Figure 1. Moringa oleifera tree.

Each jar check beaker had 500 mL of freshwater sample full. A 10 mL of MOPC formulated with varying concentrations was applied to each beaker. The stirring speed was set at 200 rpm for 4 min, and at 40 rpm for 30 min.

The heavy metal separation study utilized an Atomic Absorption Spectrometer (Analyst 400. Perkin Elmer). The calibration curve was derived from the stock solution prepared from each norm at various concentrations of any type of metal. Until AAS processing, the freshwater obtained during the jar check was purified using a vacuum pump through a container with a 0.45 µm nylon membrane.

Turbidity of a water body is a measure of the presence of soluble, suspended, and colloidal particles, which obstruct water transmission of light. Turbidity may theoretically influence photosynthesis levels, thus plant or algae development in the body of water. Turbidity may be measured directly from samples and is usually represented using NTU (Nephelometric Turbidity Units). Turbidity check for water samples was measured using a turbidity meter of 2100P (HACH) and compared before and after treatment [22]. The pH of the wastewater sample was calculated by pH meter, respectively.

Spectrophotometer was used to measure the COD. Approximately 2 mL of de-ionized water (control) was added to vials of COD digestion reagents for every sample from the test container. The samples were then put in the COD reactor, and heated for 2 hours at 150 °C to a heavy oxidizing agent (potassium dichromate solution). And the substances were cooled to usual temperature [23].

Electrical conductivity (EC) is a function of the capacity of the water to conduct an electrical current, often called simply conductivity. Hence, EC is used in a body of water to calculate salinity and dissolved salt content. The formal measure of conductivity is Siemens per meter (S/m); however, micro Siemens per centimeter (µS/cm) is more commonly used for fresh or brackish waters and millisiemens per centimeter (mS/cm) for estuarine and marine waters measurements. EC varies by temperature, and the values reported are typically set at 25 °C. Such data are called Specific Conductivity. A 5 °C difference improves conductivity by approximately 10%. Most conductivity devices have correction functions in such a way that EC can be interpreted directly at 25 °C (check the testing manual). A portable waterproof PCD 650 multifunction meter (CyberScan Waterproof Portable pH/ORP/Conductivity Meter from Eutech Instruments, Metex Company Limited) has been used to analyse electrical conductivity. Before treatment, the wastewater samples were analysed directly in situ, and then assessed after treatment.

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3. Results and Discussion

3.1 Heavy metal removal

The SWUST wastewater concentration of Cr and Cd heavy metal was respectively 2 mg/L, 4 mg/L, and 6 mg/L A jar check was conducted to assess the appropriate dose or concentration of Moringa oleifera solution applied to wastewater by applying 10 mL of 1000 ppm, 5000, 10000, 15000, 20000 and 25000 ppm to 500 mL of wastewater. Results of SWUST's heavy metal content of wastewater were obtained after treatment with Moringa oleifera solution having specific content. From the experiment results shown in Figure 2, upon treatment with MOPC the heavy metals were effectively reduced. The chromium and cadmium removal rate was 92.85 percent, and 89.84 percent, respectively. Usually the amount of metal removal increases proportionally to the MOPC solution concentration.

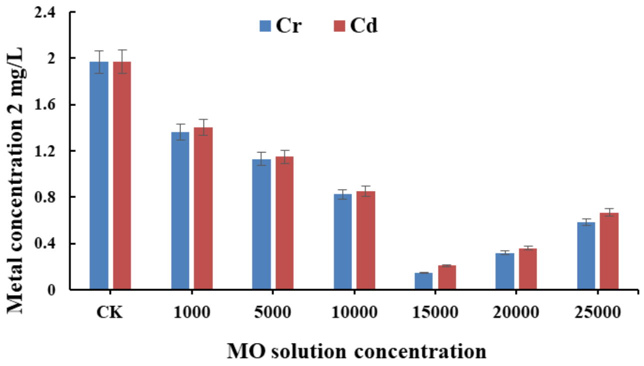

Figure 2. Removal of heavy metals 2 milligram/litter.

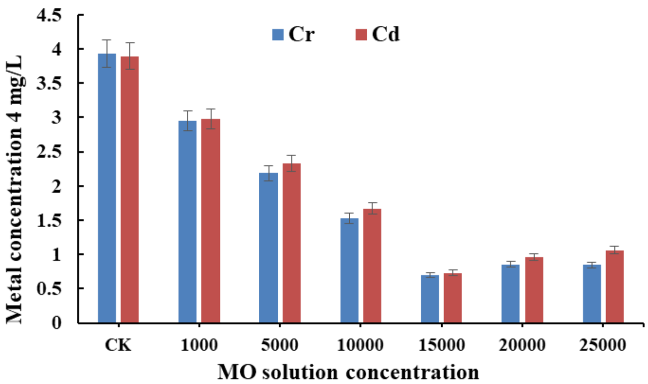

Figure 3. Removal of heavy metals 4 milligram/litter.

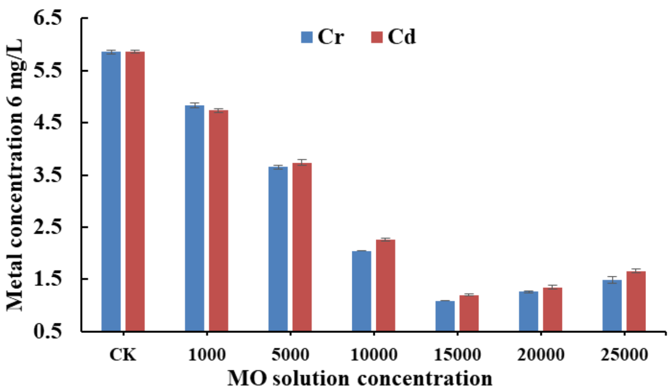

Figure 4. Removal of heavy metals 6 milligram/litter.

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From the experiment results shwn in Figure 3, upon treatment with MOPC the heavy metals were effectively reduced. The chromium and cadmium removal percentage was 82.30 percent, and 81.23 percent, for 4 milligram/litter, respectively. From Figure 4, for 6 milligram/litter, the chromium and cadmium removal rate was 81.53% and 79.52% respectively.

3.2 Turbidity analysis and pH

The wastewater had turbidity of 47.7 NTU, by incorporating MOPC, the turbidity of 20000-ppm MOPC solution at optimum concentration was lowered to a minimum value of 9.7 NTU. Figure 5 indicates the trend in turbidity decrease as the concentration of the MOPC solution increases. There is, however, a restriction on the removal of turbidity, and the continued increase of the MOPC would result in increased residual turbidity. The highest turbidity elimination rate was 79.6 per cent.

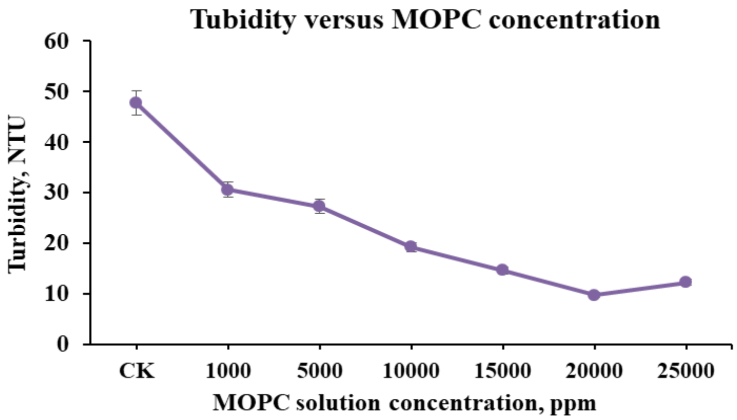

Figure 5. Turbidity of treated wastewater.

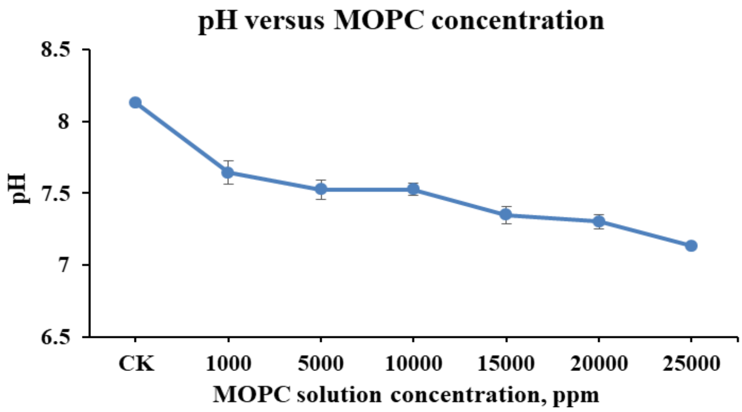

Figure 6. The pH value vs. MOPC concentration.

The pH calculation was per pH meter and the results are shown in Figure 6. The pH value varied from 8.13 to 7.13 after treatment with a specific MOPC concentration, the pH value from 8.13 to 7.13 after treatment with a specific MOPC concentration within the range accepted by the World Health Organisation of appropriate 6.5 to 8.5 levels for drinking water, was not substantially varying.

3.3 COD and EC

The wastewater COD was measured with a strong oxidizing agent (potassium dichromate solution) using the spectrometer (HACH DR2800) after heating (HACH DRB200) in COD digestion reagent vials for 2 hours at 150 °C. The results of COD are stated in Figure 7, showing that with the implementation of MOPC the COD decreased. The wastewater COD is declining from 236.3 mg/L to 98.03 mg/L at an optimum concentration of 15000 ppm. Then the COD increases marginally with

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the concentration of MOPC solution after it has reached the maximum concentration. The average percentage of COD exclusion was 58.51 percent. The values of electrical conductivity (EC) tend to be varied slightly for all sample points, ranging from 1349 to 1535 µS/cm, shown in Figure 8.

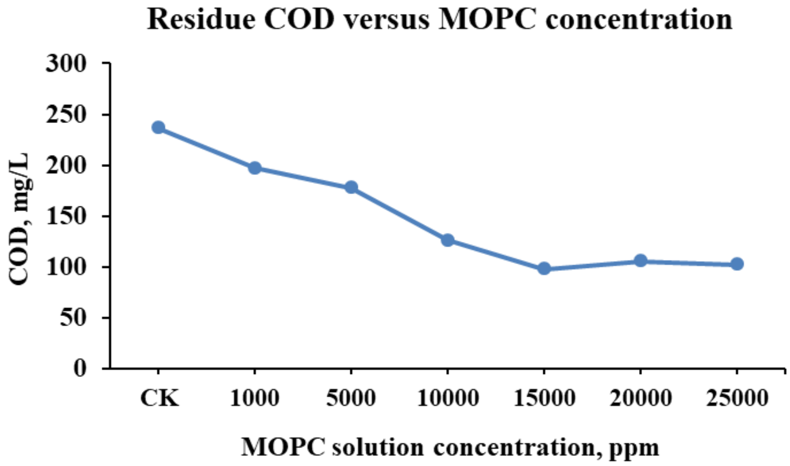

Figure 7. COD of the water vs. MOPC concentration.

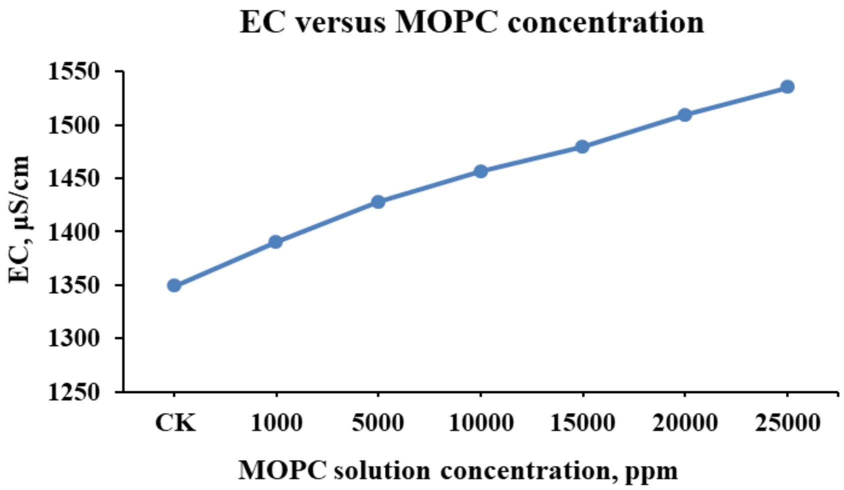

Figure 8. Electrical conductivity (EC) vs. MOPC concentration.

4. Conclusions

A significant decrease in the concentration of heavy metal after MOPC treatment was observed. The removal of chromium and cadmium (2 mg/L) was to be as 92.85% and 89.84%; for 4 mg/L, chromium and cadmium were 82.30% and 81.23%; whereas for 6 mg/L chromium and cadmium, it was noted as 81.53% and 79.52%. The trend in turbidity decrease as the concentration of the MOPC solution increases. The wastewater COD is declining from 236.3 mg/L to 98.03 mg/L at concentration of 15000 ppm. It is recommended that the Moringa oleifera press cake be a good coagulant and heavy metal remover. Because Moringa oleifera seeds are environmentally friendly and cheaper, they offer a viable alternative coagulant to alum in the treatment of rural water.

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