Utilization Of Spent Batteries Carbon Rods For The Removal Of Nickel From Water By Adsorption

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Abstract- The problems associated with unplanned and improper waste disposal has contributed significantly to the pollution and degradation of the environment (land, air and sea). Some of these substances are not biodegradable and therefore persist in the environment for a very long time. Others produce leachates with high level of toxins. It has therefore become essential to look into ways of harnessing these waste materials into more profitable ventures. In this work, carbon rods from spent batteries were used for the removal of chromium and nickel from wastewater through adsorption. These rods were used as adsorbents after activation using alkaline compounds. This study shows that waste materials can be employed to solve various problems in the environment. It was also observed that the material developed was a good adsorbent as was seen in its removal efficiency for the nickel (>60%)

1. Introduction

The problem associated with the continuous degradation of the environment seems to be unending. According to Masron and Subramaneam (2018), the quality of the environment is generally declining in most parts of the world especially in poor countries. The amount of waste generated by various industries also contributes to the degraded state of the natural environment. Rapidly growing industries, indiscriminate disposal of waste such as fertilizers and pesticides have led to an increased presence of inorganic compounds in the natural environment: soil, air and water (Briffa et. al., 2020). Plastics have been employed for various uses recently due to its versatility and relative cheap cost; however, it has been observed that they constitute a major environmental nuisance due to improper disposal (Rajmohan et al, 2019). Picanco et al (2019) carried out a descriptive study on the degradation of Miriti River in order to understand the nature and characteristics of this degradation. From the results of the study, it was observed that the degradation of the river basin was caused mainly by the presence of plastics and metallic wastes. The adverse impacts or effects of land filled construction and demolition waste on the environment and natural resources is as a result of significant increase in the rate of urbanization (Yazdani et al, 2020). An increase in civilization and urbanization is directly proportional to demand for consumer goods; consequently, there is an increased generation of solid waste and wastewater, it is therefore crucial for effective methods of environmental remediation to be promoted (Karpinska and Kotowska, 2019).

2. Environmental remediation using waste material.

The term waste refer to materials that have no value anymore and such be discarded. Most times, these waste materials are discarded in ways that harm the environment. However, a closer look suggests that these materials can be converted for more meaningful purpose for the remediation of the environment. Heavy metals like arsenic and mercury have been observed to be detrimental to human health and the major ways humans get exposed to the metals is through the consumption of heavy metal contaminated water. Asere et al (2019), carried out a review on the use of modified natural adsorbent for the remediation of arsenic from water. From this review, it was observed that treatment processes using natural, locally available materials were considerable more accessible to rural dwellers. In addition, there is

also need for some sort of modification (majorly chemical) in order to improve the performance of these materials.

The presence of mercury in the environment has been increased due to industrial activities such as coal combustion. The presence of mercury in the environment has been associated with toxicity to humans. Wang et. al. (2019), carried out a critical review on developments in approaches and methods for the removal of mercury from soil, water and air. From the study, the following techniques were recommended: Phytoremediation, immobilization with biochar plus other amendments, microbial reduction /volatilization, electrokinetics removal, constructed wetlands, enhanced thermal desorption plus soil washing for soil and solid waste; algae-based mercury removal, biochar-based mercury removal, photo catalytic nano-array for water and wastewater and catalytic oxidation/removal, co-removal of NO and mercury, advanced oxidation, biochar based flue gas treatment for air and gas treatment. A critical review on waste materials for wastewater treatment and waste adsorbent for biofuel and cement supplement application was carried out by Hossain et. al. (2020). The results of this review advocate the use of these waste materials for wastewater treatment and waste management.

Major landslide occurrences are part of problems caused by slope instability during rainfall season. Many techniques have been advocated for the stabilization of soil slope. Some of these techniques include chemical stabilization, vegetation, retaining walls and various forms of reinforcement. Gidon and Saloo (2020), studied the use of bamboo (a major construction and demolition waste) for the remediation of induced slope failures. From this reveiew, it was opined that bamboo could serve as a good reinforcement material for soil stabilization resulting in the use of waste materials for environmental remediation. There are many problems associated with coal fly ash that are as a result of coal burning. Mushtaq et. al. (2019), evaluated various applications of coal fly ash in wastewater treatment. From the results of this study; it was observed that the use of fly ash for wastewater treatment processes like filtration, fenton process, photocatalysis and coagulation had the potentials to achieve good results.

3. Materials and methods

3.1 Material Collection

The adsorbent to be used in this research work were obtained from carbon rods in spent batteries. These spent batteries were sourced from rural communities in Enugu, Anambra, Kogi and Benue states. After collection, these batteries were air dried and cut longitudinally to enable the whole length carbon rods to be extracted. These carbon rods were again air-dried and scrubbed using a hard brush to further purify the carbon rods by removing impurities that may stick to the surface of the carbon rods. Thereafter the carbon rods were crushed and stored into an airtight container ready for activation.

3.2 Preparation Of Activating Agents

For the purpose of this experiment, five different activating agents were used to activate the samples in a two-step activation process. They include Sodium hydroxide (NaOH), Sodium Carbonate (Na_2CO_3), Potassium hydroxide (KOH), Potassium Carbonate (K_2CO_3) and Zinc Chloride ($ZnCl_2$). 1 molar solution of these compounds was prepared using standard procedure and labeled appropriately. The activation of granular carbon will be done in two steps as follows

3.2.1 Thermal activation: The granular carbon rods were carbonized in muffle furnace at 600^{o}C for 6hours. The furnace was allowed to cool and the carbonized granular carbon rods

were further cooled using desiccators. The dessicators was used to ensure that granular carbon does not trap moisture from the air during the cooling process.

3.2.2 Chemical activation:

Five different beakers will be labeled SHAC, SCAC, PHAC, PCAC and ZCAC. 250grams of the carbonized granular carbon rods were weighed out five times and placed into these five different beakers. Five different activated carbon were prepared by mixing the carbon samples in the labeled container with corresponding aalkaline activating compounds until a paste is formed.

The mixtures were poured into 5 stainless flat plates that that have been previously labeled with SHAC, SCAC, PHAC, PCAC and ZCAC. These flat plates were placed in the oven for 3hours at 250^{o}C. The dried granular carbon already activated was washed with distilled water until the pH of each sample was neutral (7, using a portable pH meter), dried some more and stored in well-labeled, airtight containers.

3.3 Adsorption Experiment

Nickel: 4.48grams of $NiSO_4$. $6H_2O$ salt was dissolved and made up to one liter with distilled water to obtain a stock solution of 1000mg/l

Dilutions to this concentrations was made to obtain the following concentrations 10mg/l, 50mg/l, 70mg/l, 100mg/l, 130mg/l and 150mg/l. Dilution of the stock solution was prepared using equation (3.6)

Table 3.1 Table for concentration and volume

Desired conc (mg/l)	C_{Stock} (mg/l)	V_2 (mls)	V_1(mls)
10	1000	250	2.5
50	1000	250	12.5
70	1000	250	17.5
100	1000	250	25
130	1000	250	32.5
150	1000	250	37.5

Volume of stock solution needed to dilute to different concentrations of nickel

3.4 Calibration Of The Uv Spectrophotometer

The UV spectrophotometer was calibrated to obtain a standard calibration curve that will follow the Beer Lamberts equation for nickel.

3.4.1 Preparation Of A Standard Curve For Nickel

The stock solution 100mg/l nickel was diluted to obtain solutions of 10mg/l, 50mg/l, 100mg/l, 150mg/l, 200mg/l and 250 mg/l. The absorbance readings from the spectrometer were recorded. A graph of concentration versus absorbance was used to generate a straight-line equation. This functional equation that was generated is presented below

$$Y=mx+c \qquad \text{(3.1)}$$

Where y is the absorbance reading or machine response;

M is the slope of the graph;

C is the intercept; and

And x is the concentration of nickel that is to be calculated.

The adsorption experiment was carried out by varying two factors

i. Contact time

ii. Initial ion concentration

3.4.3 Calculation of percentage mass removal:

The percentage mass removal was used to estimate the efficiency of a given adsorbent is adsorbing chromium and nickel from wastewater. This was calculated as

$$\%M.R = \frac{c_i - c_e}{c_i} \times 100 \text{.....(3.2)}$$

Where C_i is the initial concentration; and

C_t is the concentration at time t.

3.4.4 Calculation of adsorption capacity: This was calculated using the relationship below

$$q_e = \frac{V(c_i - c_e)}{m} \text{.....(3.3)}$$

Where C_1 is the initial ion concentration;

C_t is the concentration at time t;

V is the volume of distilled water used in the dilution; and

M is the mass of the adsorbent used.

4. RESULTS AND DISCUSSIONS

4.1 COMPARISON OF ADSORPTION OF NICKEL AND CHROMIUM USING SHAC, SCAC, PHAC, PCAC AND ZCAC.

During the adsorption of nickel from wastewater, it was observed that SHAC was a more efficient adsorbent in the adsorption process at all concentrations (10mg/l, 50mg/l, 70mg/l, 100mg/l, 130mg/l and 150mg/l). SCAC was found to be more suitable than PHAC and PCAC at adsorbing nickel at concentrations less than 50mg/l. However at concentrations more than 50mg/l, PHAC was found to be more suitable in adsorption of nickel from wastewater. ZCAC was observed to be the least suitable in the adsorption of nickel at all concentrations as it had the minimum removal efficiencies of all adsorbents. This removal technique has advantage over others because it is cheap, simple, fast, and efficient and makes use of material that would normally constitute a nuisance to the environment.

4.2 Effects of Contact time

Results obtained from the analysis of the adsorption process of chromium and nickel while varying contact time showed that the removal process of nickel in wastewater increased with an increase in contact time. For nickel, equilibrium was attained fastest using SHAC after 60mins. However at higher concentrations of nickel, equilibrium time varied between 120mins to 300mins

4.3 Effects of initial ion concentration

The percentage removal of nickel by the five adsorbents showed an increase with decreasing initial ion concentration. This is due to the fact that at lower concentrations the ions of nickel in the adsorbate experience better interactions with the biding sites in the adsorbents thereby

facilitating adsorption. At higher concentrations, more nickel ions are left un-adsorbed due to saturation of binding sites

Table 4.1: EFFECT OF INITIAL CONCENTRATION

Initial ion Conc	**SHAC**	**SCAC**	**PHAC**	**PCAC**	**ZCAC**
	Ni	**Ni**	**Ni**	**Ni**	**Ni**
10mg/l	100	100	85	80	79.6
50mg/l	83.54	78.54	78.84	77.66	76.64
70mg/l	78.37	77.34	77.2	76.21	73.53
100mg/l	63.67	66.58	73.01	53.95	62.9
130mg/l	73.57	69.57	75.32	71.52	69.55
150mg/l	72.05	69.2	74.1	68.54	67.08

Conclusion

From the study, the following conclusions were made. Activated carbon can be produced from carbon rods in spent batteries and can be used in treatment process of heavy metals like nickel. The sorption capacity is dependent on contact time and initial ion concentration of nickel. The removal of nickel showed dependence on initial ion concentration

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