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Purification of Zinc Contaminated Water Using Activated Carbon, Banana and Orange Peels from Katalina Spring Banda-Nakawa Division Kampala District

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***Abstract**:*
***Background**:Water pollution by heavy metals, zinc inclusive, is becoming a major problem globally[1]. Too much ingestion of zinc causes health problems to an individual including fatigue, dizziness, nausea, vomiting, stomach crumps, damage of pancreas, and sometimes death[2]. The study aimed at purifying the zinc contaminated water from Katalina spring (Nakawa) using activated carbon, banana and orange peels.*
***Methods**: Fruit peels were collected from Banda-Kireka market and washed with water several times to remove contaminants. The peels were then washed with double distilled water to remove remaining dust contaminants. They were left to dry under sunlight for 5 days, then dried in an oven at 60^{o}C for 10 hours and at 100^{o}C for 5 hours to kill micro-organisms. The cooled peels were ground to a fine powder. Batch adsorption studies were carried out during the treatment of the zinc contaminated water and filtrates analyzed using atomic absorption spectrophotometer to determine the final zinc concentration in the filtrates. These were analyzed both qualitatively and quantitatively.*
***Results:** Activated carbon had the highest percentage removal (99.951%) followed by banana peels (70.566%) and lastly orange peels (61.253%). The paired significance mean differences indicated that there was no significant difference between the percentages adsorbed by these peels, that is,0.006963 for activated carbon and banana peels, 0.018570 for activated carbon and orange peels and 0.011789 for banana and orange peels.*
***Conclusion**: Zinc contaminated water can be purified using banana and orange peels though banana peels have a higher adsorptive capacity than orange peels.*
***Key Words**: Activated carbon, banana peels, orange peels, batch adsorption and zinc polluted water*

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I. Introduction

Water pollution due to heavy metals from industrial activities is increasing tremendously and is a matter of global concern[1]of which Uganda is no exception.In water, heavy metals like lead (Pb), scandium (Sc), cadmium (Cd), copper (Cu), and zinc (Zn) [3] are persistent and non-biodegradable hence the need to remove them before discharging the waste water into the environment.

Naturally, zinc occurs in rocks. Although zinc has been found to have low toxicity to man, prolonged consumption of large doses can result in health complications such as icterus (yellow mucus membrane) [4] fatigue, dizziness, nausea, vomiting, stomach crumps, damage to the pancreas, neutropenia and sometimes even death[2].

The conventional methods of zinc removal from water for example, use of activated carbon adsorption,reduction, precipitation, ion exchange, electrochemical reduction and reverse osmosis [5] are too expensive for ordinary Ugandans, hence the need for a cheaper yet environmentally friendly alternative for the purification of zinc contaminated waters. Recent studies have been done on the use of only one adsorbate to purify heavy metal contaminated water [6] thus creating a need to carry out a comparative study on the effectiveness of using the banana and orange peels as zinc metal adsorbates.

Oranges (*Citrus sp*) are abundantly used in soft drink industries and their peels are usually treated as wastes. The peels contain carboxyl functions of galacturonic acid and pectic substances that are known to strongly bind metal cations in aqueous solution [7]

Banana (*Musa spp*.) is one of the most favored and popular fruits in Uganda and all over the world. Peels are the major by-products obtained during the processing of various fruit products [8]. Banana peels are considered as a dominant agricultural waste from different industries that needs to be utilized. Chemically, they contain nitrogen, carboxylic acids, carbohydrates, fiber, potassium, manganese, traces of polyphenoles and ether extractives [9] that bind cations. These readily available fruit wastes can thus provide a cheaper solution if best put to use.

II. Materials And Methods

Study area: The study was carried out using water from Katalina spring located in Banda, Nakawa division, Kampala district, at coordinates 34N459763E0038650N.
Study duration: 7th January 2019 to 20th August 2019

Methods

❖ ***Water sampling***

Two water samples were collected from Katalina spring by means of 300ml Winchester bottles, which had first been washed with 10% nitric acid to prevent leaching of the zinc out of the bottles and then rinsed with distilled water (to remove all impurities) and portions of the water sample. Metal ion concentration in the water was determined using an Atomic adsorption spectrophotometer (AAS, Shimadzu AA 6300).

❖ ***Determination of zinc concentration in water from Katalina Spring after treatment with activated carbon.***

Water treatment

Water treatment was carried out at room temperature (25^0C) in a batch method. The experiments were carried out by taking two 200 ml of water samples in 500 ml beakers and after pH adjustments,1gm of the activated carbon powder was weighed using a digital balance (Mettler AE 163) and added to the beaker with the water samples. The beaker was agitated for thirty minutes using the jar test (Ece). After agitation, the suspensions were allowed to stand for one hour. The residue with adsorbed metal ion was filtered using a vacuum filter pump containing a filter paper (Whatman-42). Metal ion concentration in the filtrate was obtained using an Atomic adsorption spectrophotometer (AAS, Shimadzu AA 6300).

❖ ***Determination of zinc concentration in water from Katalina Spring after treatment with banana peels.***

a) ***Biomass preparation***

Fruit peels of bananas were collected from Banda-Kireka market. The selected peels were then cut into small pieces to allow for quicker drying and then washed with water several times to remove ash and other contaminants. This was followed by washing the peels with double distilled water to remove remaining dust contaminants. The washed peels were left to dry in sunlight for 5 days, followed by drying in an oven (Kinematica AG) at 60^oC for 10 hours so as to completely dry the peels. The peels were furthermore subjected to 100^oC for 5 hours to kill all surviving micro-organisms that would have remained on the dry peels. The brittle peels were cooled to room temperature, ground using an electronic grinder (Polymix PX-MFC 90D) to a fine powder in order to increase surface area for adsorption.

b) ***Water treatment***

Water treatment was carried out at room temperature (25^0C) in a batch method. The experiments were carried out by taking two 200 ml of water samples in 500 ml beakers and after pH adjustments,1gm of the banana peel powder was weighed using a digital balance (Mettler AE 163) and added to the beaker with the water samples. The beaker was agitated for thirty minutes using the jar test (Ece). After agitation, the suspensions were allowed to stand for one hour. The residue with adsorbed metal ion was filtered using a vacuum filter pump containing a filter paper (Whatman-42). Metal ion concentration in the filtrate was obtained using an Atomic adsorption spectrophotometer (AAS, Shimadzu AA 6300).

❖ ***Determination of zinc concentration in water from Katalina Spring after treatment with orange peels.***

a) ***Biomasspreparation***

Orange peels were collected from Banda-Kireka market. The selected peels were cut into small pieces to allow for quicker drying and then washed with water several times to remove ash and other contaminants. This was followed by washing the peels with double distilled water to remove remaining dust contaminants. The washed peels were left to dry in sunlight for 5 days, followed by drying in an oven (Kinematica AG) at 60^oC for 10 hours so as to completely dry the peels. The resulting peels were furthermore subjected to 100^oC for 5 hours to kill all surviving micro-organisms that would have remained on the dry peels. The brittle peels were cooled to room temperature, ground using an electronic grinder (Polymix PX-MFC 90D) to a fine powder in order to increase surface area for adsorption.

b) ***Water treatment***

Water treatment was carried out at room temperature (25^0C) in a batch method. The experiments were carried out by taking two 200 ml of water samples in 500 ml beakers and after pH adjustments,1gm of the orange peel powder was weighed using a digital balance (Mettler AE 163) and added to the beaker with the water samples. The beaker was agitated for thirty minutes using the jar test (Ece). After agitation, the suspensions were allowed to stand for one hour. The residue with adsorbed metal ion was filtered using a vacuum filter pump containing a filter paper (Whatman-42). Metal ion concentration in the filtrate was obtained using an Atomic adsorption spectrophotometer (AAS, Shimadzu AA 6300).

Data analysis

Data was both qualitatively and quantitatively analysed.

Qualitatively, the percentage removal of metal from the solutions was calculated using the equation below.

Percentage removal = $\frac{Co-Ce}{Co} \times 100$

Where *Co* is the initial metal ion concentration (mg/l)

Ce is the final metal ion concentration (mg/l)

Quantitative measures and the significance difference between the mean of the percentage removals for each pair of adsorbate were obtained using paired sample T-tests using SPSS 15 software package.

III. Results

Physical parameters

Table 1: Physical parameters maintained in the study

Parameter	**Value**
pH	6.5
Temperature	25^0C
Agitation speed	120 rpm
Adsorbate concentration	1.00 gm
Contact time	90 minutes

Adsorption results

Table 2: Zinc concentration in untreated water samples from Katalina spring.

Sample number	Zinc concentration in water (mg/l)
1	10.00
2	10.01
3	10.00
Mean	10.003

From Table 2, the zinc concentration in untreated water from Katalina spring was 10.003g/ml.

Table 3: Zinc concentration in water samples after treatment with activated carbon

Sample number	Initial zinc concentration (mg)	Final zinc concentration (mg)	percentage of zinc removed
1	10.00	0.0049	99.951
2	10.01	0.005	99.950
3	10.00	0.0048	99.952
Mean	10.003	0.0049	99.951

From table 3, the percentage removal of 10.003 mg/l of zinc in contaminated water sample using activated carbon adsorbate was 99.951%

Table 1: Zinc concentration in water samples after treatment with banana peels

Sample number	Initial zinc concentration (mg)	Final zinc concentration (mg)	percentage of zinc removed
1	10.00	2.944	70.560
2	10.01	2.945	70.573
3	10.00	2.944	70.560
Mean	10.003	2.944	70.566

The percentage removal of 10.003 mg/l of zinc in contaminated water sample using banana peels adsorbate was 70.566%

Table 1: Zinc concentration in water samples after treatment with orange peels

Sample number	Initial zinc concentration (mg)	Final zinc concentration (mg)	percentage of zinc removed
1	10.00	3.877	61.23
2	10.01	3.875	61.288
3	10.00	3.876	61.24
Mean	10.003	3.876	61.253

The percentage removal of 10.003 mg/l of zinc in contaminated water sample using orange peels adsorbate was 61.253%

Table 6: Table showing the significance mean differences at 95% confidence interval between the paired adsorbates

Pair no:	Pair	Significance mean difference
1	percentage of zinc removed by activated carbon - percentage of zinc removed by banana peel	0.006963
2	percentage of zinc removed by activated carbon - percentage of zinc removed by orange peels	0.018570
3	percentage of zinc removed by banana peel - percentage of zinc removed by orange peels	0.011789

There is no significant mean difference at 95% confidence interval between the paired adsorbates (Table 6).

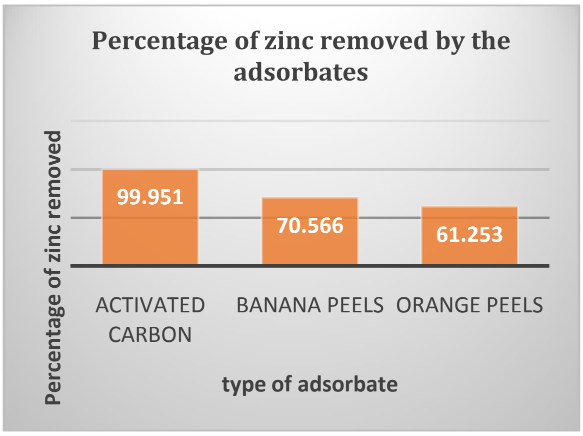

Figure I: A graph showing the percentage removal of zinc metal from contaminated spring water by activated carbon, banana peels and orange peels

IV. Discussion

The high concentration of zinc in this spring can be attributed to activities like car washing, poor disposal of domestic wastes carried out both upstream and downstream of the spring, and industrial wastewaters from galvanic industries, battery production and paint industries [11]. This high zinc concentration (10 mg/l) is unhealthy for human consumption and purification before domestic use is highly desirable.

The percentage removal of zinc by activated carbon was high (99.951%) due to the physical structure of activated carbon. It has a highly porous structure with a very large surface area brought about by its large number of cavernous pores that provide a large surface area relative to the size of the actual carbon particle and its visible exterior surface [12].

The percentage removal of zinc in the contaminated water sample using banana peels adsorbate was 70.566%. This is due to the chemical composition and physical structure of these peels. Chemically, banana peel is a good source of pectins (10-21%), lignin (6-12%), cellulose (7.6-9.6%), hemicelluloses (6.4-9.4%), galacturonic acid [9], crude protein (8%), ether extract (6.2%), soluble sugars (13.8%) and total phenolic compounds (4.8%) [13]. The pectins from banana peels contain glucose, galactose, arabinose, rhamnose, and xylose that further its adsorptive capacity of zinc ions from solution [14]. Physically, the peels have a micro porous structure, heterogeneous, rough surface with crater-like pores and the particles are of irregular shape with surface exhibits a micro-rough texture, which can promote the adherence of zinc [15].

The percentage removal of zinc from the zinc contaminated water by the orange peels adsorbate was 61.253%. This is largely due to the presence of pectin substances on the surfaces of orange peels. The pectin substances, which account for more than 40 % of the dry matter, are complex heteropolysaccharides containing galacturonic acid whose constituent carboxyl functions, pectin substances are able to strongly bind the zinc ions [10] and hence remove them from the contaminated water.

The differences in adsorptive capacity is mainly due to the differences in the physical composition of the peels. Compared to banana peels, the number of pores on the orange peel surface is less because the surface of the orange peel contains fibres that are spread throughout it [12].

The adsorption capacities of banana and orange peels obtained by this study show considerable similarity to those obtained from previous studies [16], [17] and [18], all of whichshow that despite both banana and orange peels being good adsorbates for zinc, banana peels have a higher adsorption capacity.

V. Conclusion

From the study, zinc contaminated water can be purified using banana and orange peels though banana peels have a high adsorptive capacity than the orange peels. These readily available peels, are potentially a good enivronmentally friendly yet affordable substitute for the expensive conventional methods of zinc removal, if dedicated to this use.

VI. Recommendations

For maximum utilization of these peels, research should be carried out investigating the effects of each physical parameter on the adsorptive capacity of the banana and orange peels.

Comprehensive studies ought to be done to find out whether a combined use of orange and banana peels offers any performance advantages for zinc removal.

Further research needs to be carried out on possible ways of improving the performance of each of the peels to an efficiency rate more comparable to that of activated carbon and other convectional methods of zinc removal. The adsorptive capacity of these peels should be studied for the removal of other heavy metals in water.

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