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Removal of Inorganic Anions in Brewery Effluent using Banana Peels

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Abstract

Effluents generated from industries are major contributors to various water pollution problems. This research aimed at ascertaining the removal efficiency of Cl, SO_4, PO_4, NO_3 and N in brewery effluent using ripe and unripe *Musa sapientum* (banana) peels at three different concentrations (1g, 2g and 4g). Standard laboratory techniques involving the use of Spectrophotometric methods were adopted to determine chemical properties of the effluent sample. The concentrations of the inorganic anions of the treated brewery effluent sample were observed to decline compared to the untreated effluent sample. This research work shows that banana peels are effective precursors for the removal of inorganic anions from brewery effluent.

Keywords: Banana peels, brewery effluent, inorganic anions, removal efficiency.

Introduction

Currently, the world is almost populated by seven billion inhabitants (CNN, 2011). One of the most critical problems of developing countries is improper management of vast amount of wastes generated by various industrial activities. More challenging is the unsafe disposal of effluents into the ambient environment. Effluents produced in various industries constitute potential hazards to our environment as they introduce various contaminants.

Industrial effluents are major contributors to various water pollution problems. Some of these problems include eutrophication, which can stimulate the growth of algae, increased water purification cost, interference with the recreational value of water, health risks to humans and livestock, excessive loss of oxygen and undesirable changes in aquatic populations (Akpor and Muchie, 2011). Water pollution as a result of phosphorus and nitrogen compounds has been a major source of eutrophication, hence a concern for environmentalists and environmental engineers. Also, several damages to the quality of receiving water, is due to effluent discharges from industrial and domestic wastewaters (Surchi, 2011).

In recent years, there is greater environmental awareness on the need to treat wastewater effluent before discharging into receiving water bodies. This has necessitated methods for the removal of contaminants from wastewater (Zahra, 2012). Emphasis is placed on the treatment of industrial wastewater effluent since local and international authorities require that wastewaters from industries be treated and made to meet set standards before they are discharged into the water bodies. The need of safe and economical methods for the removal of inorganic ions and other contaminants in waters has developed interest towards the search for low cost treatment alternatives. There is therefore need for agro-based, in-expensive adsorbents to be explored and their feasibility to remove these contaminants, studied (Uttam and Rajesh, 2013).

In recent years, several natural products, usually considered waste, such as sugar cane bagasse, peanut shells, corn cob, plantain peels, coconut shell and apple waste, have been reported to be used in the removal of inorganic ions (Namasivayam and Sangeetha, 2005; Castro *et al.,* 2011). Okereke et al. (2013), however suggested other devices in purifying water in homes and industries.

There is the paucity of information on the removal efficiency of inorganic anions from brewery industry using ripe and unripe *Musa sapientum* (banana) peels, hence this study..

Materials and Methods

Collection of Industrial Effluent Samples

Brewery effluent samples were collected from the outlet of Pabod Breweries Ltd, Oginigba, Trans-Amadi, Port Harcourt using sterile 4-litre plastic Can.

Preparation of Bio-Sorbent Precursor

Ripe and unripe bananas used for this research work were bought from Swali Market in Yenagoa, Bayelsa State, Nigeria. The bananas were washed in tap water to remove sand and other debris and were peeled. The banana peels were sun-dried for 8days. They were washed again after sun-drying to remove the dirt adhered during the sun-drying process. Wetted biomass were air-dried to remove free water from the surface, and dried in an oven for 4 hours at 50°C.The crispy peels were pulverised separately into fine powder using a sterilized Milling Machine. The pulverised peels were sieved through a 0.25mm sieve size and stored in air-tight bottle prior to the laboratory investigations at room temperature.

Experimental Procedure

Different concentrations of the pulverized peels were used; 1g, 2g and 4g, was mixed with 400ml of the effluent per concentration. The sample was placed in the conical flask apparatus and stirred at 120rpm speed using rotary shaker at room temperature to obtain homogenous mixture for 2 hours. After 2 hours of mixing, the sample was allowed to settle for 10 hours and filtered using Whatman no.1 filter paper to remove the biosorbent precursors. The treated effluent was then analyzed for inorganic anions.

Determination of Inorganic Anions

Inorganic anion concentrations were determined using standard procedures as described by APHA (1998).

Chloride (Argentometric Method): About 50ml of the wastewater sample was transferred into conical flask and 3 – 4 drops of indicator potassium chromate solution and standard silver nitrate solution slowly added from the burette and the solution shaken well. At the end point, light yellow colour persists. The titration was repeated until a concordant volume was obtained.

Phosphate (Ascorbic Acid Method): Effluent sample (50ml) was pipetted into an acid- cleaned, dry 125ml Erlenmeyer flask and 1 drop of phenolphthalein indicator added, when a red color developed, 8ml of 5N sulfuric acid was added until the color disappeared. The mixture was allowed at least 10 minutes (but not more than 30 minutes) for color development. Absorbance at 880nm was measured using a reagent blank to zero the spectrophotometer. The reagent blank was made using 50ml of distilled water carried through the digestion step and ascorbic acid procedure. The final concentration of phosphate was determined using the following equation: Mg/l P = mg/l from the curve x 50ml divided by initial volume used (ml).

Nitrate – Nitrogen (Colorimetric Method): The effluent sample was passed through a copper-coated Cadmium reduction column. Nitrate in the sample is reduced to nitrite in a buffer solution. The nitrite was then determined by diazotizing with sulfanilamide and coupling with N-1- naphthylethylene diaminedihydrochloride to form a colorazo dye. The absorbance was measured at 540 nm which is linearly proportional to the concentration of 'nitrite + nitrate' in the sample. Nitrate concentrations were obtained by subtracting nitrite values, which have been separately determined without the cadmium reduction procedure, from the 'nitrite + nitrate' values.

Sulphate (Turbidometric Method): Deionised water (100ml) was poured into a clean and acid-washed beaker with 50ml of buffer solution, and then transferred into a clean, 125-ml Erlenmeyer flask containing a clean magnetic stirring bar. Some 10ml of deionised water, 6 ml of buffer reagent, and 10ml of the standard solution were added into the flask. It was swirled gently to ensure mixing. About 0.1g - 0.2 g of $BaCl_2$ was added to the flask which was immediately placed on the magnetic stirrer and stirred for 58 to 62 seconds. After a minute of stirring, the solution was allowed to stand undisturbed for ~2 minutes. The absorbance was measured by a spectrophotometer at the wavelength of 420nm and sulphate concentration determined by comparison of the reading with a standard curve.

Efficiency Calculation

Removal efficiency was calculated on the inorganic anions. This was computed by subtraction of the initial concentration from the final concentration multiplied by 100 divided by the initial concentration.

Results and Discussion

Analysis of Inorganic Anions

Mean inorganic anions (Cl, SO_4, PO_4, NO_3 and N) concentrations of untreated brewery effluent samples were within the range of 5.34mg/l – 547mg/l with NO_3 recording highest; PO_4, lowest. After treatment, their concentrations decreased within the range of 516mg/l – 3.34mg/l, (Tables 1 & 2).

Table 1: Mean results for Inorganic Anions of Brewery effluent before and after treatment with ripe banana peels.

Inorganic Anions	Before Treatment	After Treatment		
		ripe 1g	ripe 2g	ripe 4g
Chloride (mg/l)	468.6	312.4	298.2	454.4
Sulphate (mg/l)	348.7	40.1	92.1	338.8
Phosphate (mg/l)	5.34	1.25	2.50	3.34
Nitrate (mg/l)	547	37.8	123.8	160.6
Nitrogen (mg/l)	123	8.5	28	36.2

Table 2: Mean results for Inorganic Anions of Brewery effluent before and after treatment with unripe banana peels.

Inorganic Anions	Before Treatment	After Treatment		
		unripe 1g	unripe 2g	unripe 4g
Chloride (mg/l)	468.6	397.6	369.2	440.2
Sulphate (mg/l)	348.7	39.8	85.8	240.1
Phosphate (mg/l)	5.34	2.23	2.90	2.50
Nitrate (mg/l)	547	516	25.8	0.00
Nitrogen (mg/l)	123	116.8	5.8	0.00

Efficiency calculation

Efficiency of percentage removal of inorganic anions on the effluent samples was calculated. The result showed that nitrate and nitrogen had the highest percentage removal with both ripe and unripe banana peels on the effluent sample (Figures 1 & 2).

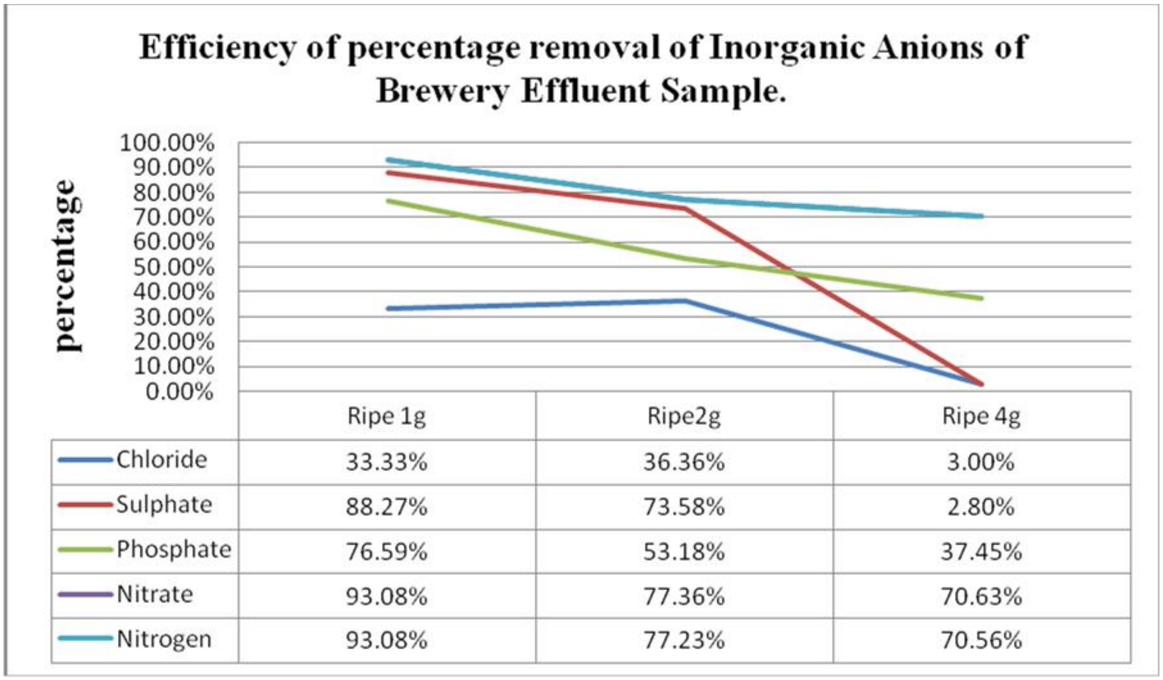

Figure 1: Efficiency of percentage removal of inorganic anions in brewery effluent sample usig ripe banana peels.

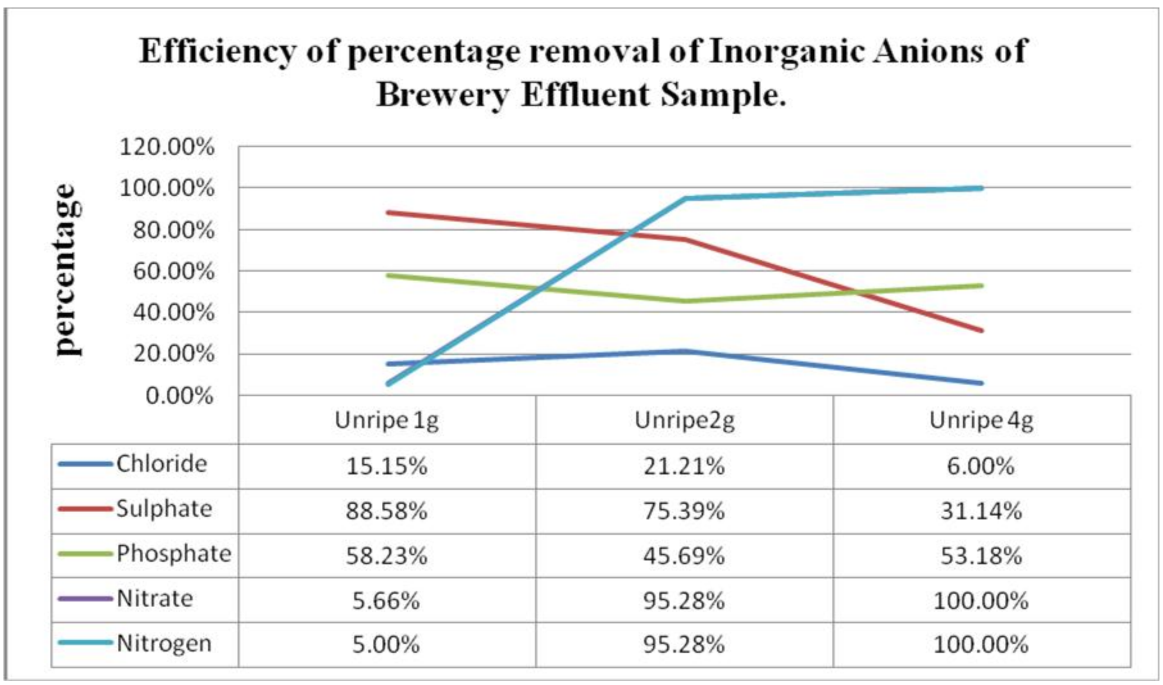

Figure 2: Efficiency of percentage removal of inorganic anions in brewery effluent sample using unripe banana peels.

Discussion

Chloride concentration must be finely tuned to the minimal inhibitory concentration (0.7 ppm) to avoid its negative effects on health and environment (Virto*et al*., 2004). However, untreated and treated brewery effluent samples had Chloride levels below (NEMA) standard.

Sulphate is an important anion imparting hardness on water. It may undergo transformation to sulphur or hydrogen sulphide depending largely upon theredox potential of water. Hydrogen sulphide commonly originates in water owning to the decomposition of organic matter or bacterial reduction of sulphate under anaerobic condition (Metcalf and Eddy, 1999). In the present investigation, the mean concentration of sulphate ranged from 39.8 to 348.7 mg/l and average value was found to be 70 mg/L, which is about 25 times higher than EPA standards.

Phosphate can be present as dissolved or particulate matter. It is an essential plant nutrient and is often the most limiting nutrient to plant growth in fresh water. Phosphates enter waterways from human and animal waste, phosphate rich bedrock, wastes from laundry cleaning and industrial processes, and fertilizer runoff (Mosley *et al.*, 2004). If too much phosphate is present, algae and water weeds grow wildly, choke the water way and use up large amount of oxygen resulting into death of aquatic organisms. According to Perry *et al.,* (2007), it is not possible to find a high phosphate reading if the algae are already blooming, as the phosphates will already be in the algae but not in water. However, phosphate is an essential nutrients to plants life, but when found in excess quantities, stimulates excessive plant growth such as algae bloom (Igbinosu and Oko, 2009). Although, both untreated and treated effluent samples are below the NEMA (1999) permissible limits (10mg/l).

The discharge of nitrate presents several water quality concerns. Nitrate contributes to eutrophication of water bodies, which eventually leads to depleted dissolved oxygen levels. In cases of direct or indirect potable reuse, nitrate is a potential health hazard. Nitrates in drinking water are associated with blue baby syndrome, and the EPA has set treatment standards (Powlson *et al*., 2008). Unpolluted water usually contain only minute amount of nitrate (Jaji *et al*., 2007). Elevated levels in nitrate have been reported to exhibit delayed reactions to light and sound stimuli and can cause methaemogloobinemia (Fatoki and Ogumfowokan 2008; Robillard *et al*., 2003). Some of the results both untreated and treated brewery effluent sample are above EPA standard.

Nitrogen is an essential plant element and is often the limiting nutrient in marine waters. The major routes of entry of nitrogen into bodies of water are municipal and industrial wastewater, private sewage disposal systems, decaying plant debris and discharge from car exhausts (USEPA, 1986).Nitrogen may cause aquatic biological productivity to increase, resulting in low dissolved oxygen and eutrophication of lakes, rivers, estuaries, and marine waters (Perry *et al*, 2007). Some of the mean results both untreated and treated of the effluent samples are above NEMA (1999) permissible limits. The high value of Nitrogen in the effluent sample is probably due to the use of food preservatives containing nitrogenous compound and presence of organic pollutants rich in nitrogen content in the effluents from the industry. Effluents from brewery industry are generally rich in protein content (Meertens *et al*., 1995).

Conclusion

This work shows that banana peels (ripe and unripe) are effective precursors in the removal of inorganic anions from brewery effluent. The cost implication of using conventional methods of inorganic anions removal from brewery effluent is high compared to using low cost agro waste (banana peels) which is economical, cost effective and eco-friendly. Therefore, we recommend that banana peels be used for inorganic anions removal from industrial wastewaters.

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