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Removal of nitrates from water by environmental waste materials

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ABSTRACT
The use of bio-adsorbents particularly environmental waste materials for the removal of various excess chemical constituents present in the water is an emerging technique. The present study investigates the use of environmental waste materials viz. orange peel and banana peel in combination for the removal of nitrates from the water. The study is carried out to identify the effect of adsorbent dosage and effect of contact time on the removal efficiency of nitrates in the water. The results indicate that there is a gradual increase in the removal efficiency of nitrates with increase in contact time of mixture of Musa Sapientum (Banana) Peel and orange peels from 15 mints to 120 mints. The maximum removal efficiency of about 86% is observed at the contact time of 1440 minutes. Removal efficiency has increased with increase of the adsorbent dosage. Of the two adsorbents mixture viz. orange peel and banana peel, banana peel dosage shows a positive relation with the removal efficiency of nitrates whereas orange peel dosage shows negative relation with the removal efficiency of nitrates in the mixture of orange and banana peels. This study concludes that the banana peel powder acts as good adsorbent along with minimum dosage of orange peel powder to remove nitrates from the water. Various other parameters viz. pH, stirring speed, initial nitrate concentration, and effect of temperature and different pre-treatment methods of adsorbent are to be studied to increase the efficiency of nitrate removal and enhance the applicability of mixture of banana and orange peels as a biosorbents on large scale treatment.

Keywords - Banana peel powder, Nitrates, Orange peel powder.

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I. INTRODUCTION

Nitrogen (N) is one of the forms of nitrate commonly found as a pollutant in both surface and ground waters. Nitrate being inorganic compounds leaches through the root zone and reaches the surface and ground waters. They are certainly ecofriendly and greatly soluble in water. The main source of nitrates is from animal waste, plant decomposition, and agricultural byproduct. The flowing water due to rain, floods, and soil erosion will transport and introduce the nitrates into groundwater supplies. It is abundant material present in our environment and very critical to the sustainability of all living creatures. Though, too much intake of nitrogen compounds can lead to health complications and illness.

Nitrates are considered to be a primary water quality contaminant, meaning the contaminant levels are enforced by law. Even since 1970s water pollution due to nitrates from agricultural activities is more dominant in North America and Western and Central Europe and has been enhanced due to industrialization in twentieth century [1, 2]. Sixty percent of higher nitrate levels in groundwater globally are identified in croplands alone [3]. The prescribed limit of nitrates suggested by WHO [4] and US EPA [5] in drinking water is 10 mg/L to avoid health hazards, but in many parts of the world it has exceeded the maximum acceptable concentrations [6,7]. Many countries are taking measures to control the nitrate pollution by allotting certain budget [8].

India has no exemption from this nitrate pollution. Even in many locations of Andhra Pradesh and Telangana mainly in the districts of Adilabad,

Anantpur, Chittoor, Cuddapah, East Godavari, Guntur, Hyderabad, Medak, Warangal, Karimnagar, Khammam, Krishna, Kurnool, Mahbubnagar, Nalgonda, Nellore, Nizamabad, Prakasam, Ranga Reddy, Srikakulam, Visakhapatnam, Vizianagaram and West Godavari the nitrate concentration in groundwater is exceeding the permissible limit (> 45 mg/L). The distribution of Nitrates in groundwater varies spatially and temporally by various factors such as availability of source, precipitation, thickness, dissolved oxygen concentrations, irrigation, ground water flow, aquifer heterogeneity, and electron donor availability and dispersion [9].

Even various methods to reduce the nitrate concentration in water have their own advantages and limitations viz. electrodialysis, reverse osmosis, biological denitrification, ion exchange, adsorption and chemical denitrification [10, 11, 12, 13]. Reverse osmosis gives fouling smell and deteriorates with time and its efficiency is not satisfactory whereas the ion-exchange method is not suitable for the high TDS water [14, 15]. Electrodialysis method has problem in waste disposal and operation [15]. Biological denitrification process is more complex and has high monitoring needs and sensitivity to environmental conditions [16]. Adsorption technique is considered to be effective method for the removal of nitrates from water because of its low maintenance cost and ease of operation which are lacking in the conventional methods [17].

Biosorption is a type of physiochemical process which uses biological materials to bind over the contaminants onto its cellular structure. Use of biomass in environmental cleanup has been in practice for a while, scientists and engineers are hoping this phenomenon will provide an economical alternative for removing toxic heavy metals from industrial wastewater and aid in environmental remediation [18, 19]. It is proven to be a cost effective method for the removal of various ions in the water [20].

Previous studies indicate that Musa Sapientum (Banana) Peel [9] and orange peels [21] separately are used as effective biosorbents for the removal of nitrates in the water. Banana peel has removal efficiency of nearly 80% when 0.05g of banana peel powder of 106 μm size fraction was used as adsorbent to treat 100 ml of water sample of 200 mg/l nitrate concentration for a contact time of 0.5h [9]. The orange peels have maximum removal efficiency of ammonia and nitrates at concentration of 4gm. The optimum biosorption of ammonia and nitrate over orange peels biosorbent was obtained at pH = 5.5, contact time = 60 min, temperature= 35 °C and agitation speed = 90 rpm.

Recent studies indicated that the use of environmental waste materials for the removal of excess chemical constituents in the water became popular because of economy factor [22, 23]. Various researchers worked on the removal of nitrates by using environmental waste biosorbents like Bael leaves (Aegle marmelos)[24], Mausmi peel powder[25], Green algal powder [26], Barks and stems of annoma squamosal [27], banana peels [9] and Greenish clay rich in free silica[28] etc. The removal efficiencies varied from one material to another depending upon their pH, contact time, adsorbent dosage, time of equilibration etc.

In view of previous studies the present study focuses to identify the effect of mixture of Musa Sapientum (Banana) Peel and orange peels [MMSPOP] on the removal efficiency of nitrates in the water. The present study is carried out in two different stages viz. effect of contact time and effect of adsorbent dosage.

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

II. MATERIALS AND METHODS

I. PREPARATION OF ADSORBENT (BANANA PEEL POWDER)

Banana peels collected from local market and were cleaned thoroughly with water and dried under sun directly for three days. The peels are dried until the colour change is obtained from yellowish tint to blackish brown colour. The peels were grounded to powder and sieved. The powders were passed through the different standard sieves of sizes 53, 75, 106 and 150μm separately and were collected at the bottom of the sieve.

II. ORANGE PEELS BIOSORBENTS PREPARATION

The Orange Peels collected from local juice shops are washed with distilled water several times to remove all dust and fine materials and sun-dried till the moisture gets evaporated and turned into fine powdered particles in an electric grinder. The dried powdered orange peels are stored in a plastic container for further use.

III. PREPARATION OF NITRATE SAMPLE

Pure anhydrous Potassium Nitrate (KNO_3) is used as the source of nitrate. A solution is prepared by dissolving 0.033g of KNO_3 in 100 ml water and entire experiments were carried out with water sample of 200 mg/L nitrate concentration.

IV. TESTING OF NITRATES PRESENT IN WATER

The nitrates testing in the laboratory is done by mixing of NaNO3 in distilled water by a simple process. Ten ml of water sample to be tested is taken in test tube and then a pinch of nitrate reagent-1(NA-1) is added and then the solution Shaked for 5 min. Allow to stand for few minutes and decant the supernatant solution (about 5 ml) to another test tube. Then three drops of nitrate reagent-2 (NA-2) is added to the supernatant solution and then mixed well. The final colour that forms is compared with nitrate colour chart and record the nitrate value after 5 mints of thorough shaking.

III. RESULTS & DISCUSSION

EFFECT OF CONTACT TIME: The effect of contact time for the mixture of Musa Sapientum (Banana) Peel and orange peels [MMSPOP] is studied by taking the 100 mL nitrate aqueous solution is added to mixture of 0.1 grams of banana peel powder and 0.3 grams of orange peel powders and was allowed for stirring for different time periods of 15, 30, 60, 120, 240, 480, 720 and 1440 minutes at a speed of 120 rpm on an orbital shaker. The solution is filtered and adsorbent is separated from the observed results indicate that the removal efficiency for the contact time of 15, 30, 60, 120, 240, 480, 720 and 1440 minutes is 48%, 56 %, 64%, 75 %, 78%, 81 %, 82 % and 86 % respectively. There is a gradual increase in the removal efficiency with increase in contact time from 15 mints to 120 mints. There after the increase is limited. The maximum removal efficiency of about 86% is observed at the contact time of 1440 minutes. Hence Contact time of 120 minutes can be considered as optimum contact time (Fig,1). the treated nitrate sample.

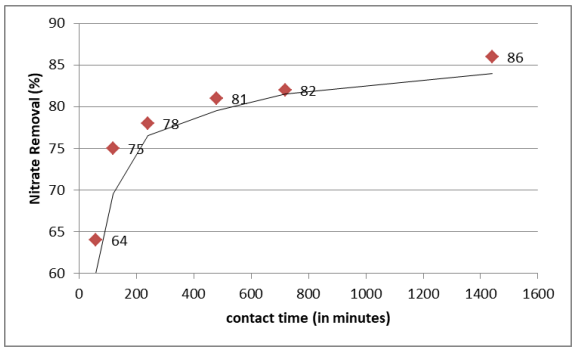

Figure 1 Effect of contact time of adsorbent on removal efficiency of nitrate

EFFECT OF DOSAGE: The effect of adsorbent dosage is experimentally identified by taking different adsorbent weights viz. 5gms, 10 gms, 15 gms, 20 gms and 25 gms respectively taking the standard contact time of 120 minutes for all the dosages. At each identical weight four different proportions of Banana Peel and orange peel powders (1:4, 2:3, 3:2 and 4:1) are taken. The removal efficiency at 5gms adsorbent dosage is 16%, 18%, 21% and 24% respectively where there is a gradual increase in the removal efficiency of nitrates with increase in the weight of banana peel powder at all weights.

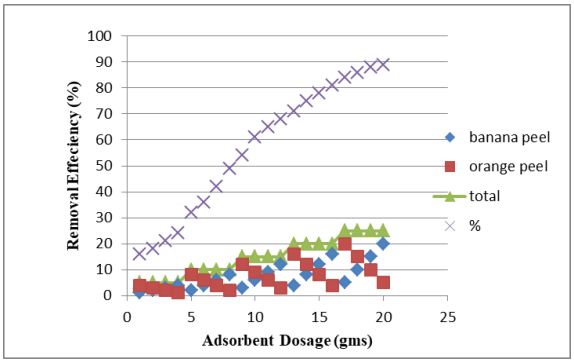

Figure 2 Effect of adsorbent dosage on removal efficiency of nitrate

Similarly there was decrease in the removal efficiency of nitrates with increase in orange peel powder dosage. This indicates that banana peel powder acts as good adsorbent along with minimum dosage of orange peel powder. At 10gms adsorbent dosage the removal efficiency is increased from 32%, 36%, 42% and 49%. And at 15 gms adsorbent dosage the removal efficiency is 54%, 61%, 65% and 68% and at 20 gms adsorbent dosage the removal efficiency is 71%, 75%, 78% and 81% at 25 gms adsorbent dosage the removal efficiency is 84%, 86%, 88% and 89% respectively (Fig.2).

IV. CONCLUSION

Utility of environmental waste materials like banana peel and orange peel for the removal of nitrates from water is proven to be a cost effective method. The present study concludes that there is a **g**radual increase in the removal efficiency of nitrates with increase in contact time of mixture of Musa Sapientum (Banana) Peel and orange peels from 15 mints to 120 mints. The maximum removal efficiency of about 86% is observed at the contact time of 1440 minutes. Removal efficiency has increased with increase of the adsorbent dosage. Of the two adsorbents mixture viz. orange peel and banana peel, banana peel dosage shows a positive

relation with the removal efficiency of nitrates whereas orange peel dosage shows negative relation with the removal efficiency of nitrates in the mixture of orange and banana peels. This study concludes that the banana peel powder acts as good adsorbent along with minimum dosage of orange peel powder to remove nitrates from the water. Various other parameters viz. pH, stirring speed, initial nitrate concentration, and effect of temperature and different pre-treatment methods of adsorbent are to be studied to increase the efficiency of nitrate removal and enhance the applicability of mixture of banana and orange peels as a biosorbents.

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