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Utilization of Pineapple crown leaf for polluted water treatment: a) bio-adsorption of dyes and b) improvement in physiochemical parameters of lake water sample

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Abstract:

Background: *Waterpollution caused by industrial wastewater is an important and hazardous problem faced by many countries. Biosorption is viewed as a valuable alternative for effluent treatment. Use of plant waste for industrial waste water treatment is attractive for industry as it may decrease the overall waste water treatment cost. Pineapple (Ananas comosus) is a tropical fruit which contains almost 40-45% of non-edible parts [1]. It is well established that the crown leaves of pineapple possess bio-adsorbing property. Therefore, the present study endeavour was carried out to study the use of crown leaves of pineapple for (a) bio-adsorption of chemical dyes like Methylene green, Congo red & Methyl orange and (b) to study its effect on polluted water parameters.*

Materials and Methods:*(A) Pineapple crown leavesprocured from local fruit market Mumbai, were used as adsorbent. Three experimental dyesviz., methylene green, congo red and methyl orange were used as absorbate in the experiment. (A) Absorbance values of dye solution treated with 3g of pineapple crown leaves were calorimetrically recorded at their suitable wavelength over different time interval.*

(B) Water sample from Masunda Lake, Thane, was treated with 20g free leaves sample stirred once daily incubated at RT. The physio-chemical parameters like total alkalinity, COD, total hardness and microbial activity were evaluated on Day 0, Day 3, Day 6 and Day 9. All the chemicals used were of analytical grade.

Results: *Significant decrease in dye concentration was observed in the aqueous solution treated with pineapple crown leaves. Also, its use has shown promising results in decreasing the physiochemical parameters of water sample, resulting in improved water quality. Reduction in concentration of Alkalinity (258-150ppm), COD (3.5-1mg of oxygen per lit.), Hardness (140-86ppm) and Microbial growth in the Masunda Lake water sample was obtained within three days of treatment. This work can have use in design of adsorption columns for dye removal and polluted water treatment.*

Conclusion: *From this study it can be concluded that pineapple crown leaves have proved to be beneficial in reducing dyes concentrations and improving water quality in terms of physiochemical parameters over short span. Easily availability of pineapple crown leaves can be put to use for economical bio-adsorption systems.*

Key words: *Pineapple; Sustainable development; Bio-adsorption; Adsorption; Physiochemical, Economically feasible.*

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I. Introduction

Water pollution caused by industrial wastewater is an important and hazardous problem faced by many countries. Wastewaters from textile, food colouring, cosmetics, dying, printing, paper-making industries are polluted by dyes. Dye pollution from industrial effluents has a direct impact on ecological equilibrium and human's health. These dyes are carcinogenic and toxic for humans as well as for aquatic life. Therefore, breaking these dyes into non-toxic substance before letting out in the water bodies is very essential.

Biosorption is a process in which solids of natural origin are employed for the removal of dyes and other contaminants in wastewater treatment systems [2]. Biosorption is a physio-chemical process and includes mechanisms like absorption, adsorption, ion exchange, surface complexation and precipitation. Biosorption is viewed as a valuable treatment option for removing pollutants from industrial wastewaters. The overall economics of the biosorption is influenced mainly by the cost of procuring/growing the biomass. Application of plant waste to remove dyes from industrial waste water is attractive for industry as it may decrease the overall effluent treatment cost. Compared to the live biomass, the use of plant waste biomass offers various advantages such as easy storage, more efficiency, easy operation and hence cost effectiveness for the treatment of large

volumes of wastewaters containing low dye concentrations, short operation time, and no production of secondary compounds which might be toxic. It is harmless, cheap, eco-friendly, highly efficient.

The exponential growth of plant waste production from the agri-food industry is a critical global issue, considering its storage and disposal. However, the exploitation of plant wastes and by-products for the recovery of added-value compounds offers new avenue for industrial growth and waste management. Utilization of waste product from fruits and vegetables is the need of the hour for sustainable development. Also, researchers are engrossed on utilization of agricultural waste for biosorption [3].

The leading edible fruit of family *Bromeliaceae* and one of the most important fruits in the world is pineapple (*Ananas comosus*). It is a tropical, perennial, herbaceous, 1-2 meters tall and wide, with leaves arranged in spiral manner[4]. Worldwide it is commercially important crop. According to FAO data base pineapple production is estimated to be more than 18 million tons, with area under plantation 920,349 ha in 2007 [5]. Studies have shown that almost 40-80% pineapple fruit is discarded as waste[6]. The increasing demand of pineapple generates a large amount of waste. Low-quality fruits are left on farm because they do not fetch market[1]and industries that produce processed products of pineapple generates waste on a large scale. Waste generated by fruits are not disposed properly due high transportation cost which leads to dumping of waste in the landfills causing environmental issues[1].

Recently, studies have focused on use of pineapple waste for production of various value-added products[7]. Many studies have successfully illustrated the use of pineapple crown as bio-adsorbent. In the current study, pineapple crown is used for adsorption of dyes like congo red, methylene green & methyl orange which causes water pollution. Pineapple crown leaves were also utilized for improving water quality till certain extend. It has proven to be beneficial in adsorption of dyes from aqueous solution and also promising results were obtained for improvement of water quality. Decreased concentration of physiochemical parameters like Alkalinity, Chemical Oxygen Demand, Hardness & Microbial growth were observed. Thus, from the results obtained it can be deduced that, this economical and feasible method can be practiced by small scale industries and large-scale industries to treat the effluent.

II. Methods & Materials

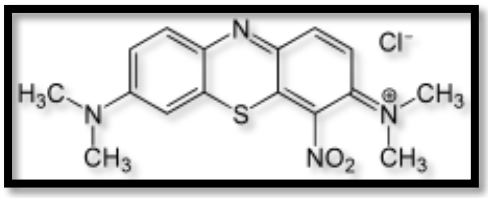
Samples –

Adsorbent - Crown leaves of pineapple were procured from local fruit market Mumbai, India.

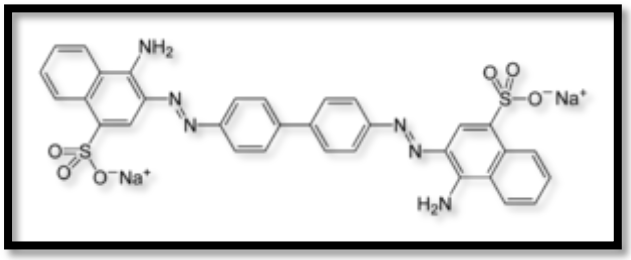
Ananas comosus crown leaves werewashed with distilled water, cut into approximately 1cm pieces.

Adsorbate – Three dyes were used in the experiment – methylene green, congo red and methyl orange.

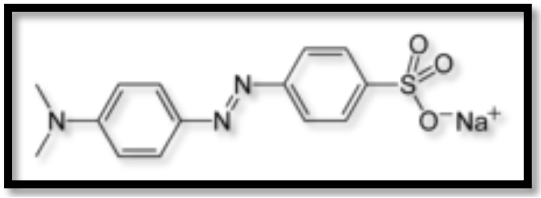
A - Methylene green is a heterocyclic aromatic chemical compound, Chemical formula - C16H17ClN4O2S, Molar mass - 364.85g/mol



B - Congo Red is an organic compound, an azo dye. Chemical formula - C32H22N6Na2O6S2, Molar mass - 696.665 g/mol



C -Methyl orangeis an intensely coloured compound used in dyeing and printing textilesChemical formula - C14H14N3NaO3S, Molar mass - 327.33 g/mol



Water sample - Water sample was manually collected from Masunda Lake, Thane, India.
Study design: Parametric analysis.
Study location: Ramnarain Ruia Autonomous College, Matunga, Mumbai.
Study 1- To study bio-adsorption property of crown leaves.
50 ml of dye solution (A- Methylene green, B – Congo red, C – Methyl orange) is to be prepared in a conical flask. The lambda max was determined for each dye solution and concentration was estimated colorimetrically. The dye solutions with 3g pineapple crown leaveswashed with distilled water, cut into 1 cm pieces, were incubated at room temperature for 5 days and stirred once daily. The experiment was performed in triplicates. A control was also run for all three dyes alongside the experimental aliquots.Readings, were recorded on Day 0, Day 1, Day 3 and Day 5.
Study 2–Tostudy change in concentration of physiochemical properties of water sample using crown leaves.
20g of crown leaves were washed with distilled water, cut into approximately 1cm pieces andsoakedin 3 litres of watersample (Masunda Lake). Readings for all the below noted experiments were taken at Day 0, Day 3, Day 6 and Day 9.

2.1 Estimation of total alkalinity of the water sample.
The procedure was carried out as described in AOAC[8]with slight modification. 25ml of the water sample was pipetted out in 250ml conical flask. About 2-3 drops of methyl orangeindicator was added. This solution was then titrated against 0.03N HCl. The end point observed was yellow to light orange. Blank titration was also performed using distilled water.
2.2 Estimation of chemical oxygen demand (COD) of the water sample.
The procedure was carried out as described in AOAC[8] with slight modification. The experiment was carried out in two steps:
Refluxing**:**25ml of the water sample was pipette out in 250ml conical flask. 25ml of 0.2N potassium dichromate and 2ml of concentrated sulphuric acid was added in the same conical flask. The contents were heated in a water bath using an air condenser, for 20 minutes. After refluxing the contents were transferred into 250ml standard flask to make up the volume with distilled water.
Standardization**:**25ml of the diluted sample was taken in a conical flask. 7.5ml concentrated sulphuric acid and 3-4 drops of ferroin indicator was added. This solution was then titrated against 0.125N ferrous ammonium sulphate till the colour change from dark orange to green and finally reddish-brown precipitate was observed.
2.3 Estimation of total hardness in the water sample.
Estimation of total hardness was carried by the procedure as described inAOAC [8]. The method was slightly modified to suit the current assay.50ml of water sample was pipette out in a conical flask and 2-3 drops of ammonium buffer (pH10) was added followed by 2-3 drops of Eriochrome Black-T indicator resulting solution was titrated against standard EDTA. The colour change observed was from wine red to blue. Blank titration was also performed using distilled water.
2.4 To study anti-bacterial property.
0.5ml pineapple crown leaves treated water sample was applied on the nutrient agar plate using spread plate technique in sterile environment. The plates were incubated for 24 hours in a sterile environment and the density of colonies were observed.

III. Results

1. To study bio-adsorption property of crown leaves
The absorbance of the aliquots of aqueous dye solutions along with the control were measured colorimetrically (Image 1 & 2). The absorbance values were noted for Methylene green(600nm), Congo red (540nm) and Methyl orange (520nm) (Table 1). With increase in the time interval a decrease in absorbance values was observed. As shown in (Fig 1).

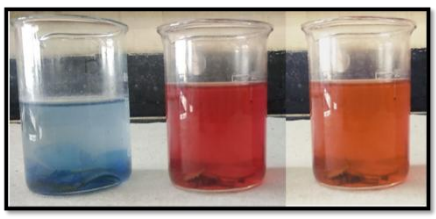


Image 1

Image 2

Image 1:Bio-adsorption property of crown leaves. Shows the absorbance of dye (Day 1)

Image 2: Bio-adsorption property of crown leaves. Shows the absorbance of dye (Day 5)

Table 1: Shows absorbance value for the dyes.

No. of days	Methylene green (600nm)	Congo Red (540nm)	Methyl Orange (520nm)
Day 0	0.87	0.79	0.69
Day 1	0.4	0.66	0.45
Day 3	0.12	0.58	0.16
Day 5	0.12	0.55	0.08

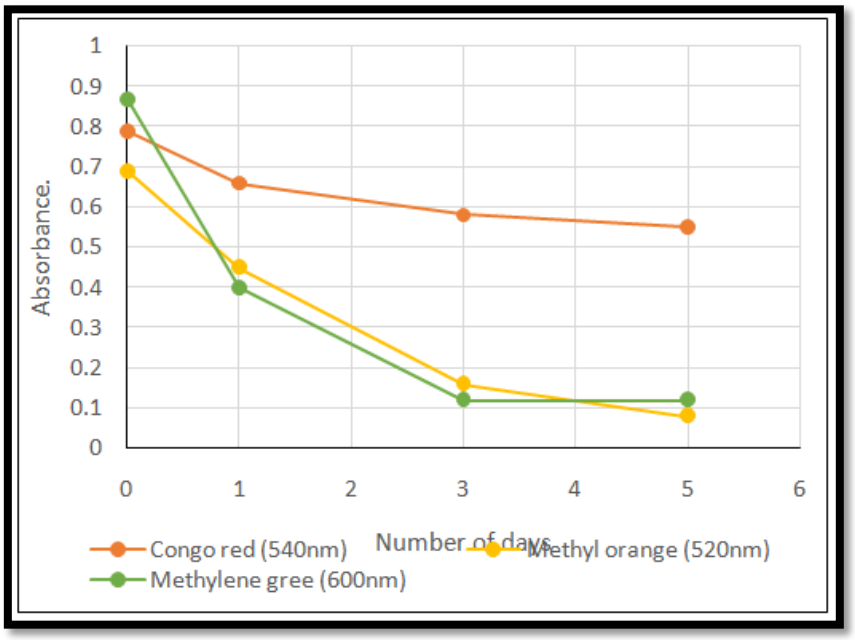


Fig 1:Absorbance of Chemical dye by crown leave.

2. Estimation of physiochemical property of water using pineapple crown.

Day 0 indicates initial concentration of the following parameters of water sample without addition of crown leaves. It was used as control.

2.1 Estimation of total alkalinity of the water sample

Total alkalinity of water sample obtained after calculation was 258ppm, 150ppm, 180ppm & 216 ppm respectively for day 0,3,6 & 9 (Fig 2). Lowest alkalinity was observed on day 3 of experiment.

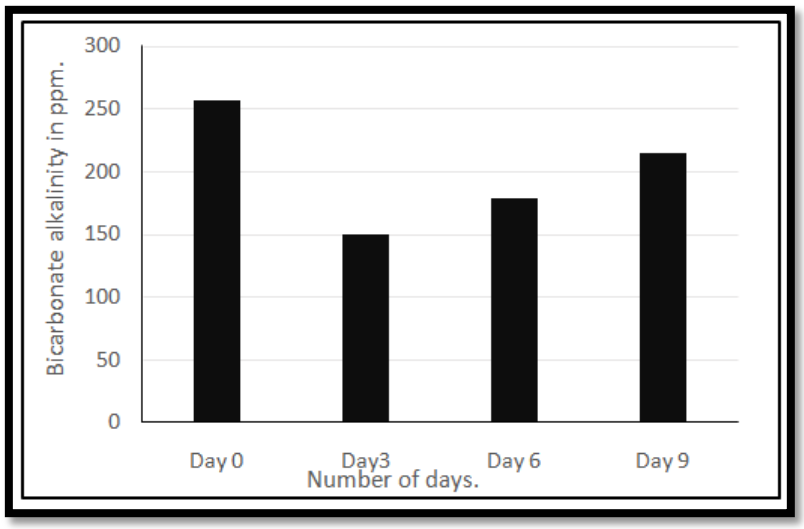


Fig.2- Total Alkalinity of the water sample.

2.2 Estimation of chemical oxygen demand (COD) of the water sample

The mg of oxygen consumed per litre on day0, day 3, day 6 &day 9 was 3.5mg, 1mg, 1.5mg & 2.5mg respectively. Lowest amount of COD was observed on day 3 of the experiment.

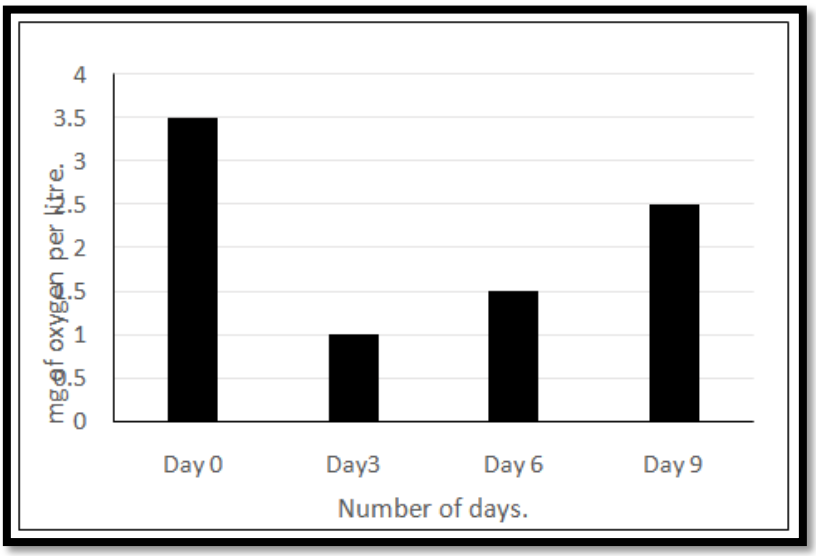


Fig. 3 – Shows Chemical Oxygen Demand of the water sample.

2.3 Estimation of total hardness in the water sample.

Total hardness obtained in the water sample after calculation on day 0, day 3, day 6 &day 9 was 140ppm, 86ppm, 100ppm & 130ppm. Lowest concentration of hardness was observed on day 3 of the experiment.

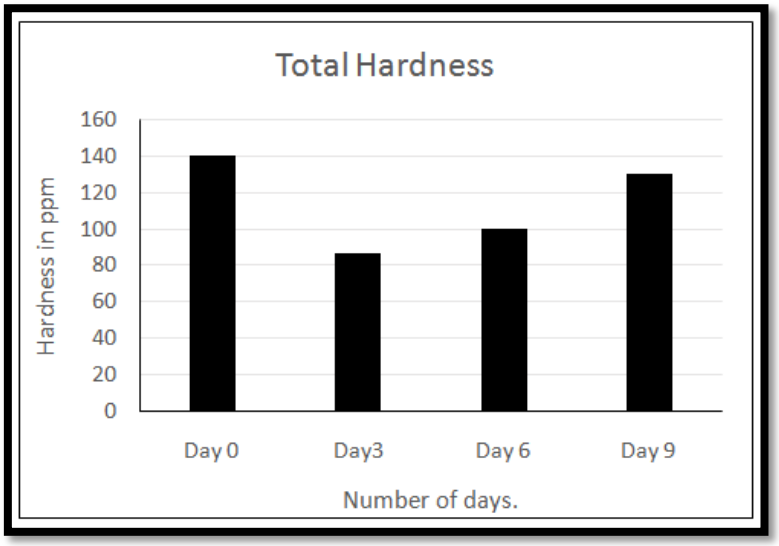
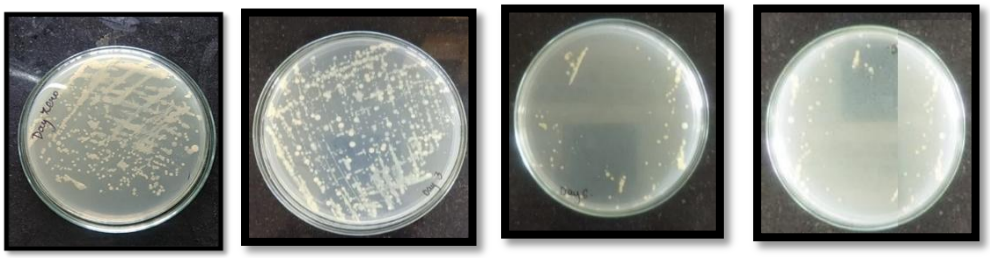


Fig.4- Shows Total Hardness present in the water sample.

2.4 Anti-bacterial property of crown leaves.



Day 0 Day 3 Day 6 Day 9

Image 3: Bacterial colony count on day 0, day 3,day 6and day 9

Decrease in density of microbial colonies was observed as shown in the above images.

IV. Discussion

Bio-adsorption of dyes by free pineapple crown leaf pieces was tested by monitoring the decrease in absorbance of each dye after different incubation time. The bio-adsorbent property of pineapple crown leaves was successfully used in reducing the concentration of experimental dyes - methylene green, congo red & methyl orange. Decreased level of absorbance were observed as follows: Congo red (0.79-0.55), Methylene green (0.87-0.12), Methyl orange (0.69-0.08).The, results showed that decrease in absorbance value of dyes was observed with increasing time interval.

The use of pineapple crown has shown promising results in decreasing the physiochemical parameters of water sample. Reduction in concentration of Alkalinity (258-150ppm), COD (3.5-1mg of oxygen per lit.), Hardness (140-86ppm)and Microbial growth in the Masunda Lake water samplewas obtained within three days of treatment.Thus, use of pineapple wastecan be practiced in small scale industries for treating its effluent which can in turn help to control water pollution to certain extend.

Many water bodies are polluted due to human interventions and industrial discharge which affects the aesthetics and quality of the water. The continuous rise in water pollution has great impact on aquatic life and non-negligible risk to soil. Biosorption system for waste water treatment is beneficial as it is economically feasible, easy to operate as compared to conventional treatment processes, non-toxic and readily available. Considering the large amount of plant waste generated from pineapple fruit, its industrial application can prove to be beneficial. If novel scientific and technological methods are applied, pineapple waste can be used for sustainable purposes.

V. Conclusion

From this study it can be concluded that pineapple crown leaves have proved to be beneficial in reducing dyes concentrations and improving water quality in terms of physiochemical parameters over short span. Easily availability of pineapple crown leaves can be put to use for economical bio-adsorption systems.

VI. Future Prospects

Further studies can be done on the active molecule in the pineapple crown leaves that is involved in the adsorbent process of dye and water purification process. Quantitative analysis can be carried out for dye bio-adsorbent assay.

More parameters of water can be taken under consideration to test the extend of purification. The effect of crown leaves in water can be studied to know whether it is safe to release in natural water bodies.

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