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RESEARCH ARTICLE

Municipal Waste Water Treatment using Plant Adsorbents

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ABSTRACT:
Access to safe drinking water is still a dream to certain category of people in urban and peri-urban areas of many important cities in India. The waste water contains a wide range of toxic derivatives, in particular heavy metals, aromatic molecules and dyes which causes a serious environmental problem owing to their potential human toxicity. Therefore, there is a need to develop technologies that can remove toxic pollutants present in waste water. Adsorption is a procedure of choice for treating industrial effluents, and a useful tool for protecting environment. This research aims to determine the best method for sustainable water purification using polysaccharides obtained from locally available waste from plants such as fruit seeds, leaves, and tubers that will help in purifying water. Large amount of municipal waste water released into environment can be treated and reused for gardening, cleaning, and washing purpose using this proposed filtration system. A unique filtration system was developed and the various types of wastewater (sewage, grey waste and dye effluent) were treated. After water analysis it was observed that the TDS was consumer acceptable, pH was neutral and we also obtained permissible limits of Mg/Fe concentration.

KEYWORDS: Heavy metal ions, Aromatic compounds, TDS, dyes.

INTRODUCTION:
Water pollution due to organic compounds and toxic metals remains a serious problem in environmental. Aromatic compounds (including phenolic derivatives, and polycyclic aromatic compounds), heavy metal ions, and dyes are often found in the environment as a result of their wide industrial uses[1]. They are common contaminants in wastewater and most of them are toxic and carcinogenic. The major pollutant in any water body is the Total Dissolved Solids (TDS) [1-4]. TDS interferes with the taste of food and beverages, and makes them less desirable to consume. A variety of health hazards are posed in some of the individual mineral salts that make up TDS.

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The most problematic are Nitrates, Sodium, Sulfates, Barium, Cadmium, Copper and Fluoride[4]. This may also cause stiffness in joints, hardening of arteries, kidney stones, gall stones, blockage of arteries and other passage in which liquid flows through our entire body[3, 4].

Heavy metal ions for example Chromium is found to be toxic to all living organisms[2]. Cadmium and mercury are known as two of the most toxic metals that are damaging the environment[6-7]. Heavy metals are not biodegradable and tend to accumulate in living organism causing various diseases and disorders. So, it should be controlled in water. Chlorinated phenols are also in priority pollutants since they are harmful to organism at low concentration[6]. Many synthetic dyes which are extensively used for textile dyeing, paper printing and additives in petroleum product are recalcitrant, toxic and mutagenic to various organisms[8].

Recently, various approaches have been studied for more effective adsorbents containing natural polymers[8]. Among these, polysaccharides obtained from plant sources used as an adsorbent material for wastewater treatment[9]. These biopolymers represent an attractive alternative as adsorbent because of their particular structure, high reactivity, chemical stability, physic co-chemical characteristics, and selectivity in aromatic compounds and metals resulting in the presence of chemical reactive group in polymer chain[10-11]. Moreover, it is well known that polysaccharides which are abundant, renewable and biodegradable source have high capacity to associate by physical and chemical interaction with a wide variety of molecules. Hence adsorption on polysaccharides derivatives can be low cost procedure of choice in water contamination for extraction and separation of compounds, and a useful tool for protecting the environment.

MATERIALS AND METHODS:

Waste Water Collection:

We have collected the samples of municipal waste water from both house and a small scale industry.

1 Sewage waste water.
2 Grey waste water (spent water from washing machine).
3 Dye effluent (from small scale Ujala dye industry).

These waste water samples were collected at Ambattur, Chennai in the month of February. Sewage waste and grey waste water from house near Ambattur and dye effluent from an industry at Ambattur. Then the samples were given for analysis at TWAD Board, state level water testing laboratory, Chennai

Water Analysis:

The collected samples were given for analysis in Tamilnadu water supply and drainage board at Chennai on 23rd February 2015. Results were given in Table.1

Substrate collection:

The adsorbents used are bio-degradable, locally available, low cost and reusable[11]. Hence this model can be scaled up without much capital cost[12]. This project will enable us to reduce the release of toxic heavy metals contained in municipal waste water into the polluted environment and help to meet the water scarcity problem globally. The adsorbents used are common solid waste available in the kitchen house thereby minimizing the solid waste disposal in houses. All the above adsorbents are collected from kitchen house and dry completely. They are processed for more surface area and made easy for cleaning and replacement.

Substrate Preparation (Adsorbents):

The substrates are prepared by the methods discussed earlier [13-23] and are given below:

Activated Carbon:

It is referred as activated coal or activated charcoal which is a common term which includes carbon material mostly obtained from charcoal. It is a material of high surface area. This is generally used as a decontaminant in the gastrointestinal tract. Since they have great advantages in the use of biomass these are used in wastewater treatment. This is because of the biomasses are renewable source that has a steady and abundant supply, domestically produced and reliable especially from agricultural activity and locally available plant waste.

Bagasse:

Bagasse fly ash is a sugar industry solid waste material, which was collected from a sugar industry. The material was treated in hydrogen peroxide at 60degree Celsius for 24hours for oxidizing the adhering organic matter. It was washed with de-ionized water, dried at 100 degree Celsius, powdered and sieved to produce desirable particle size. The material will be stored in vacuum desiccators for further use.

By keeping the material overnight in different solvents (water, dilute acids and bases) the stability of the adsorbent was determined and the presence of its constituents in the solvents was also determined.

Banana Peels:

Mature banana peels was washed several times with tap water followed by double distilled water. The double washed material was then cut in to small pieces in a hot air oven at 80 degree Celsius until a constant weight was obtained. The dried material was finely ground through the sieves of the cut of size of 150-212 micrometre. The surface area of bio-adsorbent which was prepared was found to be $456.4298 m^2 g^{-1}$.

Bamboo Leaves:

Bamboo leaves were collected and were dried at room temperature and darkness. They were sieved and grounded, and the fraction of particles smaller than 300micrometer was used for adsorption studies. Samples were stored in an air-tight plastic container and in dark condition.

Calotropis Procera:

Calotropis procera leaves were collected. Samples were washed twice with distilled water. The washed biomass was oven-dried at 50°C for 24 hours, crushed with an analytical mill, sieved and toured in polyethylene bottles.

Citrus Peels:

The peels from citrus fruits were taken for example lemon, orange and tomato. Peels were placed in an alcohol solution and it was soaked. Then the peel was removed and let for drying. After they are thoroughly desiccated and it was taken out and it was dried. Finally powder them and store it in a bottle container.

Coconut Coir:
For 3 days coconut coir dust was soaked in de-ionized water and washed several times with water until all the coloured extract was removed. It was then oven dried at 60 degree for 24hours. It was sieved to obtain particles in this range. This was stored in a plastic container.

Groundnut Shell:
Peanut shell activated carbon was prepared by 60s 90min. After they have been prepared they are finely powdered and stored in a plastic container.

Jute Fibre:
Jute is one of the affordable natural fibers. Jute fibers are primarily composed of plant material such as cellulose and lignin. The industrial term for jute fiber is raw jute. The fibers are off-white to brown and 1-4m long. Jute is also called the golden fiber.

Palm Leaves:
Dry fibers of date palm are rinsed with distilled water and it was sun dried and cut in to pieces of approximately 0.5 cm, the dead tissue samples was kept dry till the time of usage. Potassium dichromate was used as a source of chromium in the study.

Pumpkin Seeds:
Pumpkin seeds were obtained from local farm, washed and rinsed thoroughly. Soaked seeds are taken out and dried on a cooking sheet and placed in a 200F oven for an hour. The cooked seeds were then pulverized in to a fine powder in a blender and transferred to sterilized glass jar.

Working Model:
Working model consists of a tank of 25 liters capacity. It has inner pipelines which carry wastewater for purification. Primary and secondary treatments take place in the same setup.

Fig. 1 represents the simple working model for waste water treatment with capacity of 10 liters. The plant can be scaled up according to the requirement. Fig 2 shows the pipe line inside the tank.

Primary Treatment:
In the primary treatment the wastewater is fed in to the working model and the water is allowed to still until the dissolved solids sediments and collect the residue by filtering them. The residue collected is sterilized by autoclaving them and can be used as bio-fertilizer. The above collected water is sent for secondary treatment.

Secondary Treatment:
Secondary treatment of waste water has done with help of the working model has shown in the figure. The bottom part of the cane was layered with activated charcoal, then the adsorbent material was layered in the cane and above this the waste water i.e., Sewage water, Grey water and Dye effluent was poured. The wastewater poured is allowed to make contact with the adsorbent material and heavy metal ions, aromatic compounds and dyes get adsorbed to the surface of the adsorbent[24-26]. The water is collected after the treatment and sent for analysis[26].

RESULT AND DISCUSSION:
Analysis of Treated Water:
The treated waste water was collected from the tap of the cane, and the waste water was given for analysis at TWAD Board, Chennai. The analysis results were given below in Table 2.

Consumption of heavy metals like fluoride may affects the tissues, and it is reduced to 50% from its initial concentration after the treatment.

Other metal ions like iron are to be safe for the most people. But over consumption may results in stomach upset and pain and high amount of metal ions like chromium results in low blood sugar level and also affects liver, kidney. Such higher amount of metal ions level is decreased to 50% and were made in permissible limit from this waste water treatment. Reduction in the metal ion concentration are mentioned in the graphical representation below (graph 1.1 graph 1.2 graph1.3)

Adsorbent material with large surface area is used to remove all the impurities present in the waste water. The Treated water contains Aromatic compounds and Heavy metal ions concentration within the permissible limits to human. After treatment the TDS content is reduced to about 60% and the turbidity is reduced to 80% when compared with the initial concentration. The water can be used for domestic purposes in house and for cooling purpose in industries.

Figure1: Picture of the model (A) View of Outer set up (b) View of Inner pipeline

Table 1 : Physical examination and chemical examination of water samples (Before treatment)

S.No.	PARAMETERS	PERMISSIBLE LIMIT(mg/L)	SEWAGE WATER(mg/L)	GREY WATER (mg/L)	DYE EFFLUENT (mg/L)
1	Color Hazen Units	5-25	53	56	67
2	Odor	Unobjectionable	Foul Smell	Foul Smell	Foul Smell
3	Taste	Agreeable	Not Agreed	Not Agreed	Not Agreed
4	Turbidity(NTU)	5-10	82.4	61.6	54.8
5	pH	6.5-8.5	7.36	8.14	6.94
6	Total Hardness($CaCO_3$)	600	660	780	860
7	Iron(Fe)	1.0	1.71	1.82	1.61
8	Chloride (Cl)	250-1000	888	1110	990
9	Fluoride(F)	1.5	1.78	1.99	2.0
10	Dissolved Solids(TDS)	500-1000	2800	3983	2415
11	Calcium (Ca)	75-200	242	288	328
12	Magnesium(Mg)	30-100	109	132	145
13	Copper(Cu)	0.05-1.5	1.65	1.78	1.98
14	Sulfate(S)	200-400	490	360	300
15	Nitrate(NO_3)	45-100	150	134	123
16	Phenolic Compounds	0.001-0.002	0.007	0.009	0.01
17	Cadmium(Cd)	0.01	0.19	0.23	0.34
18	Zinc(Zn)	5-15	19	28	20
19	Chromium(Cr)	0.1-1.0	1.45	1.34	1.64
20	Lead (Pb)	0.05	0.18	0.34	0.32
21	Nickel(N)	0.2-2.0	3.4	5.3	4.5
22	Arsenic(As)	0.05	0.1	0.23	0.45

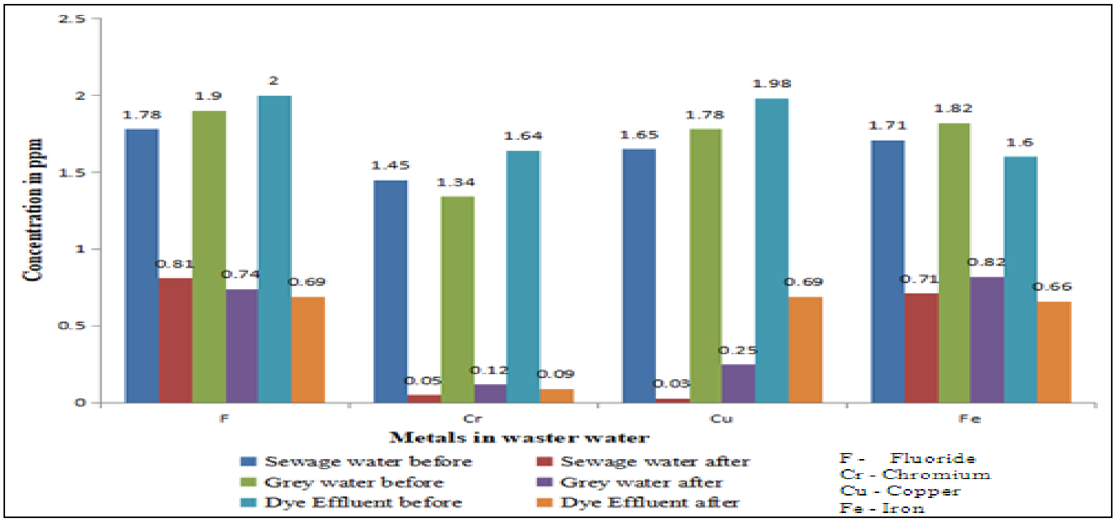
Table 2 : Substrate preparation

S.No.	ADSORBENTS	FIGURE	PURPOSE
1.	Bagasse		Removal of dye, acid orange –II (Geetha Varma et al.)
2.	Banana peels		Removal of zinc, Chromium, cadmium and nickel (Jamil Anwar et al., Dimple Lakherwal)
3.	Bamboo leaves		Adsorbs crystal violet (Ramakrishna et al., Sagnik Chakraborty et al)
4.	Calotropis procera leaf		Removal of heavy metals-cadmium (II) (Jamil Anwar et al.)
5.	Citrus peels		Removal of copper (II) (Ningchuan Feng et al)

6.	Coconut coir		removal of metal ions –Cu (II),Pb (II), Zn (II), Ni (II), Cr (vi). (Dimple Lakherwal)
7.	Groundnut shell		Adsorption of lead ions and arsenic (III), nickel (Dimple Lakherwal)
8.	Jute fiber		Removal of phenolic compounds (Ramakrishnaiah and Arpitha)
9.	Palm leaves		Removal of chromium (IV) (Namasivayam et al.)
10.	Pumpkin seeds		Removal of lead (Geetha Varma et al)

Table 3: Physical and chemical examination of water samples (After treatment)

S.NO	PARAMETERS	PERMISSIBLE LIMIT(mg/L)	SEWAGE WATER(mg/L)	GREY WATER (mg/L)	DYE EFFLUENT (mg/L)
1	Colour Hazen Units	5-25	15	23	25
2	Odour	Unobjectionable	Accepted	Accepted	Accepted
3	Taste	Agreeable	Agreeable	Agreeable	Agreeable
4	Turbidity(NTU)	5-10	3.13	4.12	2.45
5	Ph	6.5-8.5	7.36	8.14	6.94
6	Total Hardness($CaCO_3$)	600	504	478	569
7	Iron(Fe)	1.0	0.71	0.82	0.66
8	Chloride(Cl)	250-1000	488	365	690
9	Fluoride(F)	1.5	0.81	0.74	0.69
10	Dissolved Solids(TDS)	500-1000	1834	1766	1200
11	Calcium(Ca)	75-200	142	178	165
12	Magnesium(Mg)	30-100	36	38	39
13	Copper(Cu)	0.05-1.5	0.03	0.025	0.032
14	Sulfate(S)	200-400	156	254	239
15	Nitrate(NO_3)	45-100	36	43	54
16	Phenolic Compounds	0.001-0.002	0.005	0.0003	0.00026
17	Cadmium(Cd)	0.01	0.0045	0.0036	0.0021
18	Zinc(Zn)	5-15	4.5	3.6	2.56
19	Chromium(Cr)	0.1-1.0	0.05	0.12	0.09
20	Lead(Pb)	0.05	0.02	0.024	0.034
21	Nickel(N)	0.2-2.0	0.84	0.65	1.34
22	Arsenic(As)	0.05	0.034	0.045	0.023



Graph1: Comparative metal ion concentrations before and after treatment

CONCLUSION:

From the study it was observed that the parameters like color, odor, taste, pH, hardness, turbidity and proportions of many metals in the sewage water, grey water and dye effluent were in the permissible limit after consecutive treatment with different adsorbents. The only parameter that was not achieved was the total dissolved solid which was slightly higher than the prescribed amount. Further studies are undergone to reduce the TDS value and shall be reported in the future.

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