Marine brown algae *Sargassum myriocystum* biomass as potential adsorbent for the removal of pollutants from battery slag leachate

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Abstract

The objective of this study is to present an overview of current challenges and the role of marine algal biomass in leachate treatment. Metals in atmosphere know how to be dangerous for healthiness along with the majority of organisms. Industrial pollutants prior to discharge into surroundings are supposed to eradicate as of industrialized wastes containing pollutants. In this study, the physicochemical characteristics of battery slag leachate were studied. The solid waste (battery slag) was changed into leachate by percolating it with water. The physico-chemical parameters specifically appearance, colour, turbidity, TDS, TSS, EC, BOD and COD, pH, total alkalinity, total hardness, iron, nitrate, chloride, fluoride, sulphate and phosphate along with heavy metals of battery slag leachate be examined. *After treatment with the biomass Sargassum myriocystum all the physicochemical parameters are within the standard limits (FEPA).*

From the study i*t was fulfilled that the solid slag has more harmful pollutants. Heavy metal lead is the major widespread pollutant in the humankind and significant quantity of lead has been deposited in earth owing to human behavior in the earlier period. Lead is potentially noxious; consequently the description of its performance in industrial solid slag leachate is necessary.*

Keywords: Battery slag, Solid waste**,** leachate, brown algae, *Sargassum myriocystum,* adsorption.

Introduction

Environmental contamination is the solitary problem being faced by the society at present[1]. Water is considered to be an essential and incomplete resource. Numerous heavy metals and their compounds are toxic, although some are subjected to biomagnifications. Heavy metal exclusion from wastewater is significant for the safety of the human fitness and atmosphere. Occurrence of these heavy metals in wastewaters poses an essential trouble for the atmosphere[2].

Soil pollution through inorganic metals is the most important disquiet; due to its elevated amount they damage individual life as well as the atmosphere[3]. One time if the metals are dumped in the environment, they are not degraded and keep on in the surroundings for extended occasion as well as give severe ecological contamination[4].

Millions of citizens expire every year as a outcome of insecure water or poor sanitation. In developing countries, heavy metals are the main pollutants in oceanic, lake and ground waters as well as in industrial and even treated effluents. Long-standing supply of polluted effluents for agriculture improves organic carbon concentration and heavy metal content in soils as well as the probability of their entry into food chain eventually leading to major health distress[5].

An assortment of industries creates and releases wastes containing diverse heavy metals into the surroundings such as electric appliance manufacturing, aerospace, surface finishing industry, battery manufacturing, electro osmosis, leatherworking, electrolysis, metal fertilizer manufacturing, pesticide industry, mining, smelting of metalliferous, atomic energy installation, photography, energy and fuel production and recycling[6]. Lead-acid batteries are the prime cluster of presently used batteries. Yearly earth construction is about 360 million batteries among total weight of over 6840 million tons. Many reused lead battery companies <150 kilo ton mostly make use of physical dismantling for 60% to 70% in the manufacturing.

Several industries make use of reverberatory furnace, cupola and old-fashioned technologies and in some companies they use smelting kiln by no ecological safety amenities[7]. More than 90% of vehicle second-hand lead batteries are used universally. The usual car battery contains 60-80 % recycled lead holding a standard of 7.94 kg lead and 5.68 liters of sulfuric acid[8]. Many banned companies used to cut the batteries with the help of axes and smelt it together along with plastic boxes and lead grids in a reverberatory furnace without any protective measures. Recovery percentage is also very low with excess pollution discharge[9].

Battery slag produced in the rotary furnaces is separated as harmful waste and each ton of metallic lead produced 100-400 kg of slag. In developing countries, the solid waste was dumped in open area, when water percolating through pollutants from the solid waste penetrates into soil. This liquid passing through the solids leachate accumulates at the base of the landfill and percolates throughout the soil[10]. Solid waste leachate is generated when liquid percolates throughout ravage in the landfill. The water come in contact with solids come from various forms such as from air, from nearby land, from waste or due to heavy rain[11]. Lead deposits in the human body, even a small amount are able to ultimately leading to poison. More than 95% of lead in the human is stored in the bones and teeth[12]. Metal poison can cause nervous system damage kidney failure and blood pressure[13]. Maximum level of lead exposure might cause miscarriage in pregnant women and decrease the sperm development.

An Environmental Protection Agency restriction for lead in drinking water is 15 μg/L[14]. During rainfall, the solid ravage located in the dumps receives water as well as the by-product of its breakdown shifts on the stream. The liquid flowing over the waste contains numerous organic and inorganic compounds said to be "leachate".

As a result, there was necessity for a cost-effective and wide-ranging technique to the treatment of multifaceted effluents[15]. Adsorption with adsorbent is an option to accessible effluent management technique by hopeful outcome at practical level[16]. Adsorption is the capability of dead or live biomass, for example dried macroalgae, inactively bind metal ions from solutions[17]. Dried marine algae are mainly successful adsorbents owing to elevated quantity of functional groups with tough binding for dissolved metals as well have moderately elevated amount of these similar metals in the biomass.

The carboxylic groups of alginates in brown algae are characteristically leading during sorption processes and can be able to inactively attach dissolved metals during a range of processes with electrostatic attraction, ion exchange or complexation[18,19].

Leachate if not treated will contaminate the surrounding soil and natural water source. Extensive studies have investigated the characterization of many landfill leachates but not much work has been carried out on lead-acid battery slag leachate.

Material and Methods

Battery slag (Solid waste): The recycling battery industry solid waste is collected together from Kuruchi, Coimbatore, Tamilnadu (Fig. 1).

Preparation of battery slag leachate: The solid waste samples were pooled, mixed well, dried and sieved to get a homogenous mixture which was used for all studies. Leachates were prepared by the addition of 100 g slag to 1L of distilled water, nonstop shaking for 24 h at 37°C[20], then allowed to stand for 30 minutes to settle down suspended particles and filtered. Suspended matters were further removed by centrifugation and samples were sealed in screw-capped tubes at 4± 1°C for further use. As soon as leachate samples were collected, its electrical conductivity was calculated and then stored at 4°C and analyzed within 2 days according to the respective standard methods[21].

Collection, preparation and pre-treatment of the biosorbent: The brown algae were collected from Vedhalai, Ramanathapuram District, Tamil Nadu. The collected species were authenticated and shown as in fig. 2. The brown algae were washed carefully in the direction of eradicate unknown particle similar to sand and garbage. The biomass was dried out and kept in oven at 80°C till it attained stable mass, milled and stored at room temperature in polyethylene bottles.

The scientific classification of *Sargassum myriocystum* is as follows:

Kingdom	:	Plantae
Phylum	:	Heterokontophyta
Class	:	Phaeophyceae
Order	:	Fucales
Family	:	Sargassaceae
Genus	:	*Sargassum*
Species	:	*Sargassum myriocystum*

Algal Biosorbent was washed separately by 0.1 N solutions each of HCl, H_2SO_4, HNO_3 and H_3PO_4.

Fig. 1: Slag generated during battery recycling

Fig. 2: ***Sargassum myriocystum***

Characterization of the battery slag leachate: The leachate sample was analyzed for the following physical as well as chemical parameters including appearance, colour, turbidity, dissolved solids, suspended solid, electrical conductivity (EC), biological oxygen demand, chemical oxygen demand, alkalinity, hardness, iron, nitrate, chloride, fluoride, sulphate, phosphate and heavy metals such as lead, cadmium, nickel and arsenic.

Biosorption of battery slag leachate by using the biomass *Sargassum myriocystum*: Leachate of various concentration with 2g of *Sargassum myriocystum* was adjusted at 6. After 2 hours (based on optimization studies), the sample was centrifuged. The physicochemical characteristics and heavy metals in the sample were analysed.

Results and Discussion

Characterization of battery slag leachate before and after treatment with biosorbent: Disposal of recycled lead acid battery slag causes environment pollution due to the presence of toxic heavy metals with lead as the predominant one. As the leachate from used lead-acid battery recycled solid waste contains high concentration of lead and other heavy metals along with various hazardous organic matters, the removal of these toxic components based on COD and BOD from leachate is the main prerequisite before the leachate comes in contact with water bodies[22]. Hence, leachate of the recycled battery slag was prepared and characterized. The leachate was then subjected to biosorption for the of removal heavy metals with the selected biomass.

Physico-chemical characterization of battery slag leachate: Physico-chemical management of leachate is the most regular practice for the elimination of unmanageable and toxic pollutants. There are several methods such as physicochemical and biological, intended to treat wastewater with elevated levels of lethal contaminants. The treatment method selection will mostly depend on the characteristics of the leachate and process expenditure. Physico-chemical treatment would be a healthier choice for this type of leachate. The physical parameters namely appearance, colour, turbidity, total dissolved solids (TDS), electrical conductivity (EC), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD) of battery slag leachate are represented in table 1.

It was reported that the leachate was brownish in colour. The dark colour might be the presence of high amounts of FeS, PbS and various minerals from the solid waste. The turbidity was 8.73 for untreated leachate and for biomass treated leachate it was reduced within the limits. Turbidity of the leachate might be the presence of finely divided suspended and colloidal forms along with increased concentration of different ions and other pollutants. Hence, turbidity is a good parameter to measure the degree of pollution of water.

Total dissolved solid in leachate increases for the reason that of total inorganic salts and other substances that are dissolved in leachate. High TDS rate might cause salinity problem when irrigated to plants. The concentration of untreated leachate was 3678 mg/L which was higher than the acceptable standards of 2000 mg/L and for the biomass treated leachate; it was reduced within the limits. The value obtained for biomass treated leachate was much less than the tolerance limit (0.0 to 2,000 mg/L) prescribed by FEPA. The reduction of TDS in the biomass treated leachate agrees with the report in textile industrial effluent treated with unicellular green algae *Chlorella vulgaris* and *Scenedesmus obliquus*.

A total suspended solid in the leachate was superior to that of the acceptable range (30 mg/L) and for the treated leachate, it was found to be decreased. Electrical conductivity of the stream is the significant factor to decide the fitness of water for agriculture purpose. This is due to the abundance of dissolved metals or minerals. In untreated leachate, the highest value obtained was 15 mho/cm and for the biomass treated leachate it was reduced which could be due to the reduction of chloride, sodium, magnesium, sulphate, nitrate and phosphate after treatment period.

The EC values for the untreated leachate were not in the normal value of 2.25 mho/cm and for this reason they are unfit for irrigation. High conductivity value of untreated leachate may be attributed to high dissolved salts and metals in the leachate. Thus suitable treatments are essential as previously they are exposed to the sewage.

The BOD is the factor widely familiar to determine the contamination load of waste water. BOD calculates the quantity of O_2 need by means of microbes used for splitting down to simpler as of the organic substances there in stream. The BOD value of untreated was 297 and that of biomass treated leachate was 45. From the BOD results we conclude that the water gets polluted and not fit for drinking and BOD was said to be the pollution indication.

COD is investigating contamination of household as well as industrialized throw away. It is helpful in indicating poisonous state in addition to the presence of natural substances. The COD of raw leachate in this experiment was 487 mg/L and so as to biomass treated leachate it is 130 mg/L. High COD of untreated leachate sample indicates the threat of high contamination of ground water. The chemical characters for instance pH, total alkalinity, total hardness, iron, nitrate, chloride, fluoride, sulphate and phosphate of battery slag leachate are represented in table 2.

The pH value was found to be 9.4. This was due to the CO_2 produced in the landfill and concentration of the acids as both are responsible for the pH of the leachate. After treatment with algal biomass, the pH reduced and within the standard limits. Leachate by means of elevated or low down pH is not appropriate for plant growth. When the pH is low in leachate, the solubility of metals was high as well as it will be dangerous to the surroundings, whereas at high pH, the majority of the metals turns into insoluble and gathers in the activated sludge and soil sediments. Total alkalinity in untreated leachate was 120.3 mg/L and that of biomass treated leachate was reduced within the permissible limits. Total hardness in untreated leachate was 460.2 mg/L and that of biomass treated leachate was reduced three times after treatment with biomass.

Hardness is developed by a range of soluble multivalent metals, mostly calcium and magnesium and other cations similar to manganese, strontium, barium, zinc, iron with anions namely bicarbonate, sulfate, chloride and nitrate.

Table 1
Physical characterization of leachate before and after treated with *S.myriocystum*

Parameters	Before treated	After treated	FEPA standards[23]
Appearance	Turbid	Clear	NM
Color (pt.co-scale)	Brownish black	Light brown	NM
Turbidity (NT units)	8.73	3.1	NM
Total dissolved solids (mg/L)	3,678	750	2,000
Total suspended solids (mg/L)	320	14.8	30.0
Electrical conductivity (mho/cm)	15	1.7	2.25
BOD_5 at 20°C (mg/L)	297	45	50.0
COD (mg/L)	487	130	400.0

Table 2
Chemical characterization of leachate before and after treated with *S.myriocystum*

Parameters	Before treated	After treated	FEPA standards[23]
pH	9.4	7.3	6.0-9.0
Total Alkalinity (mg/L)	120	67.2	200
Total hardness (mg/L)	460	130	400-2,000
Iron (mg/L)	50	0.016	20.0
Nitrate (mg/L)	48	8.1	20.0
Chloride (mg/L)	865	380	600.0
Fluoride (mg/L)	1.1	0.01	2.0
Sulphate (mg/L)	640	65.3	500.0
Phosphate (mg/L)	0.8	0.01	5.0
Lead (mg/L)	220	0.53	<1
Cadmium(mg/L)	12.2	0.23	<1
Nickel(mg/L)	25.7	0.8	<1

The nitrate content of untreated battery slag leachate was 50 mg/L, higher than the FEPA standards (20 mg/L) and in biomass treated leachate, it was reduced to 8.1. The occurrence of high nitrate level within untreated leachate can cause contamination of nearby float up water in addition to groundwater. Nitrate results in blue baby syndrome.

The chloride level in the untreated leachate was found to be 865 mg/L indicating that biomass treatment resulted in a reduction of chloride and was within the tolerance limit (600 mg/L). Elevated chloride content in water bodies can cause damage to agricultural crops, metallic pipes and is harmful to public.

Fluoride content of untreated leachate was 1.1 mg/L which was slightly higher than the FEPA standards (1.0 mg/L) and in biomass treated leachate, the fluoride content was found to be 0.01 mg/L. Sulphate level in the untreated leachate was found to be 640.3 mg/L and in the biomass treated leachate it is within the tolerance limit prescribed by FEPA standards for sulphate (500 mg/L). Phosphate level in the untreated and biomass treated leachates was found to be 0.8 and 0.01 respectively. The most important sources of phosphate in ground water are household sewage, detergents, industrial effluents and agricultural runoff with fertilizers.

Heavy metal analysis of untreated and biomass treated battery slag leachate: Heavy metals are among the most common environmental pollutants and become an environmental problem concerned. In the leachate samples, various metals namely lead, cadmium, nickel and arsenic are deemed to be hazardous to the environment and public health. Table 3 illustrates the concentration of heavy metals such as lead, cadmium, nickel and arsenic of biomass treated and untreated leachate. There was a tremendous reduction in quantity of metals namely lead, cadmium and nickel in the biomass treated leachate when compared to that of untreated one and was in the order of sorption, Pb > Ni> Cd. This suggests that the biomass *Sargassum myriocystum* is highly effective in adsorbing all the metals studied with the maximum sorption of lead.

Conclusion

Pollutant removal from leachate is mainly difficult; conventional removal processes are at present low in efficiency or high in cost and this makes it hard to apply them practically to leachate treatment. Innovative biosorption processes have vital advantage in leachate treatment. The range of physicochemical characteristics of raw leachate be above the acceptable limits (FEPA) and after treatment with the biomass, the levels were within the limits.

On the basis of the present study, it is evident that *Sargassum myriocystum* is an effective biosorbent which adsorbs most of the pollutants in the battery slag leachate. The study also suggested that the biomass can be effectively used as an alternative to conventional treatment systems designed for the elimination of poisonous metals as of the leachates of battery recycling industrial wastes. Such solid waste is not supposed to discharge in to nearby irrigate or else earth devoid of management. Leachates generated from solid waste are unhealthy in favor of plant growth and cause severe ecological harms and will have an effect on plant, animal as well as individual life.

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