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Bioremediation of industrial waste water by low cost natural absorbents A Laboratory scale study

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ABSTRACT
Water resources are becoming more and more limited nowadays, and many of them are contaminated by human sources such home trash, industrial waste, and agricultural waste. Wastewater treatment is still essential before letting it into natural water streams. The primary goal of wastewater treatment is to eliminate the several pollutants that are present in the wastewater, including suspended particles, organic carbon, nutrients, inorganic salts, heavy metals, pathogens, and others. The preservation of human health and the environment is the primary objective of wastewater treatment. In this research work Laboratory size bioreactors were examined for the treatment of industrial effluent including sulphates and heavy metals. The bacterial consortia were created in 1.3 litre bioreactors with organic substrates (cow, goat, vermicompost and sugarcane waste ,fruit waste) and were moistened with whey from dairy products. Industrial wastewater was placed and tested for pollutant removal after a 17-day incubation period. Samples were taken after a retention periods. The research outlined in this paper serves as the basis for the creation of a new treatment technique in India for industrial wastewater with comparable properties. Gaining understanding of the pollutant removal mechanisms was possible, but it was outside the purview of this work to construct a fundamental model of the mechanisms.
***Key Words**: Industrial wastewater, bioremediation, organic waste, heavy metals*

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INTRODUCTION

Water contamination in India as a result of the dumping of heavy metals is still a major problem globally. Polluted industrial waste water treatment is still an issue on a global scale. Waste water gathered from businesses, towns, and municipalities must eventually be redirected to receiving water and land. Heavy metals have been released into the environment due to industrial activity such as mining, electroplating, tanning, metallurgical operation, and manufacturing [1]. The majority of the aforementioned companies use water in various processes, and the wastewater they produce is now being discharged as industrial effluents into untreated natural drainage systems. Industrial effluents that are released are low in pH and high in metals and sulphate. Acidic industrial effluents must be treated before being released into public waterways. The awareness about the environment protection and the need for compliance of stringent requirements of regulatory agencies, it has become mandatory for all the industries to adopt water pollution control measures so that assimilative capacity of the receiving water bodies / soil do not get adversely affected. Not all the industrial units are treating their effluents before discharging to the natural drainage .Some are just attempting to treat chemically to pretend the fulfillment of legal requirements imposed by State Pollution Control Board. The pollutant parameters in the industrial area's final effluents are significantly higher than those allowed by Bureau of Indian Standard and the Ministry of Environment and Forests.

Construction of water pollution control facilities for urban areas has tended to use concrete and steel alternatives using diverse physical, chemical, and biological ideas during the past several centuries [2]. The need for more eco-friendly, cost-effective, and straightforward (requiring fewer skills) treatment systems has been felt strongly due to the rising capital as well as operating and maintenance expenditures in chemical treatment technologies .Growing interest in the application of biological techniques for the remediation of various waste waters has been observed in recent years. The pollution brought on by these metals can be lessened by the adsorption of heavy metals employing various agricultural and fruit wastes as well as many other manure byproducts as inexpensive adsorbents. Heavy metals discharged with industrial trash have to be recycled in order to preserve the precious metals [3]. The usage of biological materials derived from complexes with metal ions employing their functional group is known as biosorption. [4] Krishnani *et al.* Different activities, including complexation, chelation, ion exchange, coordination, precipitation, and reduction, can occur with metals in different parts of the cell [5]. Since the majority of these techniques are expensive, underdeveloped nations cannot afford them. As a result, agriculture, fruit, and organic waste were used to remove heavy metals. Fruit waste is distinguished by its accessibility, affordability, environmental friendliness, and high capability to absorb heavy metals due to the presence of functional groups that can bind metals and remove them from effluents. In A viable alternative to chemical remediation is bioremediation of industrial effluents involving bioreactors and microbial populations [6]. The industrialized nations have invested in its development over the past few years to the point that it can successfully compete with and supplant competing technologies for the full-scale commercial treatment of industrial effluents [7]. sulphate reduction in bioreactors. Under anaerobic conditions sulphate reducing bacterias reduce sulphate to sulphide, which forms metal sulphide precipitates [8]. The SRBs represents a group of chemoorganotrophic bacteria strictly anaerobic bacteria [9]. By giving these sulfate-reducing bacteria a carbon source to eat, the bacterial colony is strengthened. As energy sources for SRBs, a variety of organic substrates and cellulosic wastes have been employed, with the majority being common fermentation byproducts, such as manures. As financial limitations play a significant role in underdeveloped nations, the usage of garbage, which is highly viable, was chosen as the carbon source.

Among the available treatment processes, now a days the application of biological processes is gradually gaining momentum. Considerable attention has been paid towards the development of bioreactors in the biological processes for the treatment of low pH and toxicmetal loaded effluents. In these reactors microorganisms grows in the provided medium and reduces sulphates to sulphides. The sulphide that is generated can subsequently precipitate metals metal sulphides. These bioreactors need the addition of biodegradable organic materials to supply carbon for activities that generate anaerobic alkalinity

This treatment technology is self contained, self sustaining and also economically andeffectively treats acidic and metal loaded effluents. By using sulphide precipitation, this provides an additional and effective method of cleaning industrial effluent.

The present stage of development study reveals that bioreactors can be reliably implementeda single permanent solution for polluted drainages and at a much lower cost than physico-chemical treatment. In short with the technology currently is being recommended the years of global environmental mistreatment can begin to be reversed.

Thus, environmental protection today is no longer only a desirable objective but anattainable goal. It is not mere issue of ethics but one that is linked with the survival of mankind and economic growth .By scanning through the Indian scenario, we feel optimast and are confident that the day is far of, may be sometimes in the beginning of this century, when our rivers will be once again clean, atmosphere devoid of pollutants and we will enter into a golden era where population will be stabilised, industrial wastes are recycled, forest cover is restored and eco system is balanced.

The goal of this research study has been to devise an environmentally-benign cost effective treatment technology for industrial wastewater. Current methods are impractically expensive for usage at industrial sites, necessitating the development of this new technique.

MATERIALS AND METHOD

Cow manure, goat manure, vermicompost and fruit waste were among the various organic waste sources utilised in this setup. Manures and fruit trash were gathered from city juice stands and local farms. After gathering, each item was dried before being hand ground into fine powder. In comparison to commercially available compounds, all three of the organic substrates were deemed to be potentially appropriate in terms of economic aspects.

Experimental set up

Four sets of nine 1.3 L glass jars each worked as a bioreactor (Named A, B, C, D) with different substrate combinations. Firs t set with three columns named as A1, AII, and AIII having same composition of substrates. Likewise, other three more sets were with B I, BII, BIII; CI, CII, CIII respectively. All the three column glass jars of the same set had same composition of substrates but different all the three sets.

Each jar has a total height of roughly 30 cm. Each jar was first filled to a height of 8 cm with substrate, after which a 6 cm layer of pebbles (with an average size of 1–1.5 cm) was added. After that, whey (100 ml) was added to each jar to serve as a medium for the sulfate-reducing bacteria culture. Whey served as a source of SRB , was collected from local milk dairy . For good growth and development of SRBs the substrates were moisture with whey(whey is locally available at zero or negligible cost) and covered with sand and stone layers(In previous laboratory research for low pH, metal-loaded wastewater treatment tests, it was discovered that the sand layer in the culturing vessel was of utmost relevance for the sulphate reduction [10, 11] and sealed with airtight lids to establish anaerobic conditions for bacterial cultivation for a few days (varying times for different setups, such as the incubation period). Whey was found to have 50g lactose, 6g protein, 6g ash, and 0.3g fat per litre, as was previously reported.

Table1: Glass jars (bioreactors) with their corresponding substrate compositions

Glass jars(bioreactors)	Substrates
A (AI, AII ,AIII).	70%Cowmanure,20%fruitwaste,5%urea,5%pH neutralizer
B (BI,BII, BIII).	75%Goatmanure,15% fruitwaste,5%urea,5%pH neutralizer
C(CI,CII,CIII).	80%vermicompost,10%fruitwaste,5%urea,5%pH neutralizer

The glass jars were subsequently filled with 850 ml of industrial waste water following a 17-day incubation period at room temperature. Wastewater was gathered from a nearby industrial area's open drainage. SRB's culture was confirmed by the formation of a black film at the intersection of the substrate and sand stone layer and the smell of H2S. Then, glass lids were placed on top of these jars to provide anaerobic medium. Then, to maintain a constant volume of wastewater in each bioreactor, 50 ml samples of wastewater were removed from each jar and added 50 ml at a time. After retention periods of zero, five, ten, fifteen, thirty, forty-five, sixty, seventy-five, ninety, and one hundred and five days, observations were made.

Figure 2. All the bioreactors after filling industrial waste water.

Observation table

All chemical parameters, including pH, electric conductivity, total hardness, acidity, alkalinity, sulphate, and metal ions, were assessed in the laboratory. For the metal ions tests, 50 ml filtered samples were preserved using nitric acid in accordance with Standard Methods for the Examination of Water and Wastewater (APHA, AWWA, WEF 1992).

Regular monitoring of industrial wastewater before and after bioreactor treatment showed that acidity, sulphates, and heavy metals were effectively removed. All of the bioreactors' samples were taken on a regular basis. Low pH and the presence of metals including cobalt, zinc, copper, lead, manganese, nickel, and iron are two characteristics of industrial effluent. The table1 summarises the water chemistry of the bioreactor 'industrial waste water treatment process.

Table 1.Change in pH of industrial waste water in the bioreactors

Bioreactor	pH after different retention period(days)									
	0	5	10	15	30	45	60	75	90	105
A1	6.80	6.92	8.95	8.50	8.70	8.50	7.96	7.64	7.86	7.58
A2	6.80	6.95	8.55	8.30	8.54	8.84	7.94	7.8	7.74	8.15
A3	6.80	6.94	8.54	8.50	8.74	8.54	7.98	7.9	7.73	8.64
Mean	**6.80**	**6.93**	**8.68**	**8.43**	**8.66**	**8.62**	**7.96**	**7.78**	**7.77**	**8.12**
B1	6.80	7.22	7.58	8.2	7.84	8.4	7.95	7.7	7.68	8.2
B2	6.80	8.01	7.54	7.4	7.50	7.3	7.4	7.7	7.84	8.1
B3	6.80	7.10	7.7	7.4	7.54	7.4	7.74	7.8	7.81	8.8
Mean	**6.80**	**7.44**	**7.60**	**7.6**	**7.62**	**7.7**	**7.69**	**7.73**	**7.77**	**7.36**
C1	6.80	7.17	7.41	7.83	7.48	7.9	7.87	8.03	8.36	8.43
C2	6.80	7.05	7.4	7.72	7.6	7.81	7.82	8.05	8.04	8.48
C3	6.80	7.25	7.36	7.77	7.8	8.28	7.15	7.19	8.23	8.26
Mean	**6.80**	**7.15**	**7.39**	**7.77**	**7.62**	**7.99**	**7.61**	**7.75**	**8.21**	**8.39**

Table2 change in electric conductivity (µs/cm)of industrial waste water in the bioreactors

Bioreactor	EC after different retention period (days)									
	0	**5**	**10**	**15**	**30**	**45**	**60**	**75**	**90**	**105**
A1	10,270	10,980	9860	9620	8350	8246	7900	7510	7480	7420
A2	10,270	10,950	9800	9500	8380	8288	7950	7550	7550	7300
A3	10,270	10,830	9840	9650	8540	8424	8230	7679	7980	7280
Mean	**10,270**	**10,920**	**9833**	**9590**	**8423**	**8319**	**8026**	**7579**	**7670**	**7333**
B1	10,270	10,470	9850	8300	8245	8920	8260	8110	7400	7180
B2	10,270	10,910	9749	8150	8250	8210	8810	7910	7360	8100
B3	10,270	10,500	9889	8920	8127	8190	8110	7950	7490	7830
Mean	**10,270**	**10,626**	**9829**	**8456**	**8207**	**8440**	**8393**	**7990**	**7416**	**7830**
C1	10,270	10,380	10,101	8830	7666	7610	7560	7400	7920	7120
C2	10,270	10,420	10,105	8546	7590	7490	7490	7380	7610	7260
C3	10,270	10,820	10,200	8549	7970	7610	7540	7410	7210	6980
Mean	**10,270**	**10,540**	**10,135**	**8641**	**7742**	**7570**	**7530**	**7396**	**7580**	**7120**

Table3 change in sulphate (mg/l) concentration of industrial waste water in the bioreactors with time.

Bioreactor	SO4afterdifferentretentionperiod(days)									
	0	**5**	**10**	**15**	**30**	**45**	**60**	**75**	**90**	**105**
A1	1390	1350	1260	1165	1190	1090	920	900	630	650
A2	1390	1230	1290	1179	1156	1080	1120	750	865	740
A3	1390	1560	1180	1185	1150	1110	970	760	655	752
Mean	**1390**	**1380**	**1243**	**1176**	**1165**	**1093**	**1003**	**803**	**716**	**699**
B1	1390	1250	1260	1250	1400	1170	970	840	670	775
B2	1390	1600	1200	1270	1130	1400	955	870	750	650
B3	1390	1590	1350	1140	1205	1150	930	810	850	720
Mean	**1390**	**1480**	**1270**	**1220**	**1245**	**1240**	**951**	**840**	**756**	**715**
C1	1390	1190	1190	1120	1157	1130	860	880	660	720
C2	1390	1290	1230	1140	1175	1140	990	850	710	700
C3	1390	1256	1290	1270	1360	1340	1120	845	790	690
Mean	**1390**	**1245**	**1236**	**1176**	**1230**	**1203**	**990**	**858**	**720**	**703**

Table 4 change in acidity (mg/l as CaCO3) of industrial waste water in the bioreactors

Bioreactor	Acidity after different retention period(days)									
	0	**5**	**10**	**15**	**30**	**45**	**60**	**75**	**90**	**105**
A1	225	223.1	218	195	227	154	125	190	114	125
A2	225	254.1	226	215	215	189	190	150	157	122
A3	225	237.6	215	225	154	195	125	120	125	128
Mean	**225**	**238**	**219**	**219**	**198**	**179**	**146**	**153**	**132**	**125**
B1	225	222	109.6	109	208	205	166	123	145	124
B2	225	280	285	285	266	169	195	171	190	128
B3	225	189	255	255	224	200	167	108	185	254
Mean	**225**	**230**	**216**	**216**	**232**	**191**	**176**	**134**	**173**	**168**
C1	225	205	225	225	157	137	185	185	116	105
C2	225	201	236	236	163	145	192	196	113	111
C3	225	199	257	257	187	149	149	195	96.5	106
Mean	**225**	**201**	**239**	**239**	**169**	**143**	**175**	**192**	**108**	**107**

Table 5 Change in alkalinity (mg/l as CaCO3) of industrial waste water in different bioreactors

Bioreactor	Alkalinity after different retention period(days)									
	0	**5**	**10**	**15**	**30**	**45**	**60**	**75**	**90**	**105**
A1	0	358	335	326	350	450	448	551	634	620
A2	0	340	324.5	324	263	230	450	413	496	551
A3	0	331	320.1	320	255	38 0	413	450	427	482
Mean	**0.00**	**343**	**323**	**323**	**289**	**353**	**218.5**	**471**	**519**	**551**
B1	0	303	372	372	400	405	404	380	435	413
B2	0	654	431.4	431.4	480	435	431	454	672	656
B3	0	358	375	375	450	455	442	372	450	689
Mean	**0.00**	**438**	**392**	**392**	**443**	**431**	**425**	**402**	**519**	**586**
C1	0	344	420	420	482	538	538	547	492	482
C2	0	441	482	482	266	427	425	434	437	689
C3	0	354	427	427	372	445	442	417	441	448
Mean	**0.00**	**379**	**443**	**443**	**373**	**470**	**468**	**466**	**456**	**539**

Table 6 change in hardness (mg/lasCaCO3) of industrial waste water in the bioreactors

Bioreactor	Hardness after different retention period(days)									
	0	**5**	**10**	**15**	**30**	**45**	**60**	**75**	**90**	**105**
A1	780	750	740	690	698	700	710	650	680	620
A2	780	758	700	685	658	689	700	610	652	540
A3	780	730	690	650	655	650	680	625	645	600
Mean	**780**	**746**	**710**	**675**	**670**	**679**	**696**	**628**	**659**	**586**
B1	780	737	730	710	755	740	700	685	654	510
B2	780	785	700	715	740	749	685	690	585	500
B3	780	740	689	700	780	729	705	640	600	554
Mean	**780**	**754**	**706**	**708**	**758**	**739**	**696**	**671**	**613**	**521**
C1	780	744	758	590	690	660	650	689	680	480
C2	780	731	700	680	660	654	505	554	510	458
C3	780	755	640	710	500	620	540	415	420	450
Mean	**780**	**743**	**699**	**660**	**616**	**644**	**565**	**552**	**536**	**462**

Table 7 change in concentration of Pb (mg/l) of industrial waste water in the bioreactors

Bioreactor	Lead concentration after different retention period(days)		
	0	**55**	**105**
A1	1.2552	0.1445	0.1352
A2	1.2552	0.1432	0.080
A3	1.2552	0.1534	0.1594
Mean	**1.2552**	**0.1470**	**0.3648**
B1	1.2552	0.1483	0.1101
B2	1.2552	0.1318	0.1054
B3	1.2552	0.1314	0.1097
Mean	**1.2552**	**0.1371**	**0.1064**
C1	1.2552	0.1325	0.1116
C2	1.2552	0.161	0.121
C3	1.2552	0.171	0.1215
Mean	**1.2552**	**0.1548**	**0.1179**

Table 8 change in concentration of Zn(mg/l)of industrial waste water in the bioreactors

Bioreactor	Zinc after different retention period (days)		
	0	**55**	**105**
A1	2.305	0.985	0.0215
A2	2.305	0.981	0.0863
A3	2.305	0.912	0.0231
Mean	**2.305**	**0.9593**	**0.1129**
B1	2.305	0.989	0.0845
B2	2.305	0.814	0.0841
B3	2.305	0.791	0.0434
Mean	**2.305**	**0.864**	**0.0706**
C1	2.305	0.851	0.0082
C2	2.305	0.752	0.0194
C3	2.305	0.646	0.0154
Mean	**2.305**	**0.749**	**0.0143**

Table 9 change in concentration of Cu (mg/l)of industrial waste water in the bioreactors

Bioreactor	copper concentration after different retention period(days)		
	0	**55**	**105**
A1	3.5420	0.294	0.1172
A2	3.5420	0.296	0.1552
A3	3.5420	0.289	0.011
Mean	**3.5420**	**0.291**	**0.094**
B1	3.5420	0.952	0.1135
B2	3.5420	0.825	0.1257
B3	3.5420	0.879	0.1174
Mean	**3.5420**	**0.894**	**0.118**
C1	3.5420	0.952	0.116
C2	3.5420	0.831	0.1045
C3	3.5420	0.862	0.121
Mean	**3.5420**	**0.881**	**0.113**

Table 10 change in concentration of Co(mg/l) of industrial waste water In the bioreactors

Bioreactor	Cobalt concentration after different retention period(days)		
	0	**55**	**105**
A1	2.15	0.881	0.0655
A2	2.15	0.845	0.0774
A3	2.15	0.752	0.0625
Mean	**2.15**	**0.826**	**0.0681**
B1	2.15	0.1136	0.064
B2	2.15	0.3912	0.0539
B3	2.15	0.959	0.0717
Mean	**2.15**	**0.487**	**0.060**
C1	2.15	0.746	0.079
C2	2.15	0.719	0.076
C3	2.15	0.833	0.07
Mean	**2.15**	**0.766**	**0.058**

Table 11 change in concentration of Mn(mg/l) of industrial waste water in the bioreactors

Bioreactor	Mn concentration after different retention period(days)		
	0	**55**	**105**
A1	3.705	1.912	0.013
A2	3.705	1.566	0.043
A3	3.705	1.856	0.015
Mean	**3.705**	**1.778**	**0.023**
B1	3.705	1.746	0.058
B2	3.705	1.794	0.043
B3	3.705	1.612	0.032
Mean	**3.705**	**1.717**	**0.044**
C1	3.705	1.611	0.018
C2	3.705	1.521	0.042
C3	3.705	1.314	0.053
Mean	**3.705**	**1.482**	**0.376**

Table 12.Change in concentration of Ni (mg/l) of industrial waste water in the bioreactors

Bioreactor	Nickel concentration after different retention period(days)		
	0	**55**	**105**
A1	2.505	1.622	0.052
A2	2.505	1.339	1.72
A3	2.505	1.01	1.98
Mean	**2.505**	**1.323**	**1.250**
B1	2.505	2.959	1.672
B2	2.505	2.670	1.552
B3	2.505	2.030	1.587
Mean	**2.505**	**2.644.**	**1.603**
C1	2.505	2.113	1.417
C2	2.505	2.118	1.175
C3	2.505	2.21	0.025
Mean	**2.505**	**2.147**	**0.872**

Table 13. Change in concentration of Fe (mg/l) of industrial waste water in the bioreactors

Reactor	Iron concentration after different Retention period (days)		
	0	**55**	**105**
A1	13.4145	7.532	1.879
A2	13.4145	6.431	1.835
A3	13.4145	6.643	1.231
Mean	**13.4145**	**6.868**	**1.648**
B1	13.4145	6.542	1.721
B2	13.4145	8.541	1.313
B3	13.4145	7.432	1.164
Mean	**13.4145**	**7.505**	**1.399**
C1	13.4145	6.521	1.752
C2	13.4145	7.542	1.208
C3	13.4145	6.514	1.204
Mean	**12.4145**	**6.859**	**1.388**

RESULT AND DISCUSSION

Industrial waste water is characterized by low pH and pollution with metals like cobalt, zinc, copper, lead, manganese, nickel, and iron. Regular monitoring of industrial waste water before and after treatment in bioreactors revealed efficient removal of heavy metals, sulphate, hardness, conductivity, and acidity. Bioreactor-based bioremediation of industrial waste water is a highly promising treatment method. It is clear that the costs of operating are low and the goods are thrown away. Effect of different organic substrates in removing different pollutants from industrial water, such as pH- The pH of input industrial wastewater in the bioreactors A (average of AI, AII, AIII), B (average of BI, BII, BIII), and C (average of CI, CII, CIII) was 6.80 with various substrate compositions of A, B, and C.

In the bioreactor A, pH of treated industrial wastewater successfully increased to 6.93, 8.68, 8.43, 8.66, 8.62, 7.96, 7.78, 7.777.86 and 8.01 in five, ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days .In the bioreactor B, pH of treated industrial waste water successfully increased to 7.44, 7.60, 7.6, 7.62, 7.7, 7.69, 7.73, 7.77 and7.36 in, five ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days. Similarly in bioreactor C, pH increased to 7.15, 7.39, 7.77, 7.62, 7.99, 7.61, 7.75, 8.21, 8.29.in five, ten Fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days.

Electric conductivity –The overall ionic strength present in the industrial effluent is represented by electric conductivity. The various bioreactors' input industrial wastewater had an electrical conductivity of 10.270s/cm.

In bioreactor A electric conductivity of treated industrial wastewater with substrate composition of cow manure and fruit waste was observed as 10,920, 9833, 9590, 8423, 8319, 8026, 7579,7670, 7333 µs/cm. The nutrients of organic substrates in the water are to blame for this rise in conductivity since they cause dissolved ions to increase. Electric conductivity of treated industrial wastewater in reactor B with substrate composition of goat manure and fruit waste was observed as 10,626, 9,829 , 8,456 ,8,207 ,8440, 8,393 ,7,990 ,7,416 and 7,830µs/cm. In the bioreactor C with substrate composition of vermin compost, fruit waste and the electric conductivity of output after treatment was observed as10,540,10,135,8641,7742,7570,7396, 7580 and 7,120µs/cm in five, ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days.

Sulphate(SO_4^{2-})–One of the most typical contaminants in industrial effluent is sulphate. In the several bioreactors (A, B, C, and D), the input industrial wastewater had a sulphate concentration of 1390 mg/l.

In bioreactor A sulphate concentration of treated industrial waste water with substrate composition of cow manure and fruit waste successfully decreased to 1380, 1243, 1176, 1165,1093,1003,803,716,699mg/l. In bioreactor B with substrate composition of goat manure and fruit waste sulphate concentration successfully decreased to 1480, 1270, 1220, 1245, 1240,951,840, 756 and 715 mg/l .In bioreactor C with substrate composition of vermin compost and fruit waste sulphate concentration successfully decreased to 1245, 1236, 1176, 1230, 1203, 990, 858,720, 703mg/l in five ,ten ,fifteen ,thirty ,forty five, sixty, seventy five, ninety and one hundred five days .

Acidity – The pH and metal ions in the industrial effluent are represented by it. The different bioreactors (A, B, and C) with variable substrate composition had an acidity of 225 mg/l as input industrial waste water (as $CaCO_3$).

Acidity in bioreactor A with substrate composition of cow manure and fruit waste decreased successfully to 238, 219, 211, 198, 179, 146, 153, 132 and 125mg/l (asCaCO3) infive, ten fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days.

In bioreactor B acidity of treated industrial wastewater with sub strate composition of goat manure and fruit waste decreased successfully 230, 216, 224, 232, 191, 176, 134, 173, and 168mg/l (as CaCO3)in five, ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days. In bioreactor C with substrate composition of vermin compost and fruit waste acidity of output industrial wastewater decreased successfully to 201, 239, 177, 169, 143, 175,192, 108 and 107mg/l (as CaCO3) in five ,ten ,fifteen ,thirty, forty five, sixty, seventy five, ninety and one hundred five days.

Alkalinity–It is the water's ability to neutralise acids. It helps with process interpretation and management for the treatment of wastewater and water. Input industrial wastewater had 0 mg/l of CaCO3 alkalinity in the three separate bioreactors (A, B, and C).

In bioreactor A with substrate cow manure and fruit waste in alkalinity of industrial wastewater increased 343, 338, 323, 289, 353, 218.5, 471, 519 and 551mg/l(asCaCO3) infive, ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days. In bioreactor B with substrate goat manure and fruit waste alkalinity increased to 438, 487, 392, 443, 431, 425, 402, 519 and 586mg/l (as CaCO3)in. five, ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days. In bioreactor C with substrate vermin compost and fruit waste alkalinity increased to379,327, 443, 373, 470, 468, 466,456 and 539mg/l (as $CaCO_3$) in five ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days.

Hardness –It is the concentration of multivalent metallic cations in the solution. The bioreactors (A, B, and C input)'s industrial wastewater had a hardness of 780 mg/l (as CaCO3).In bioreactor A with different substrate compositions hardness of treated industrial waste water decreased successfully to 746,710, 675, 670, 670, 679, 696, 628,659 and 586 mg/l (as $CaCO_3$)in five ,ten ,fifteen ,thirty, forty five, sixty, seventy five, ninety and one hundred five days. IN bioreactor B hardness of output decreased successfully to 754, 706, 708, 758, 739, 696, 671, 613and 512 mg/l(as CaCO3)in five, ten, fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days. In bioreactor C hardness of treated industrial wastewater decreased successfully to 743, 699, 633, 616, 644, 565, 552, 536 and 462mg/l(asCaCO3)infive, ten Fifteen, thirty, forty five, sixty, seventy five, ninety and one hundred five days.

Metals –Industrial effluent had a high concentration of dissolved metals due to its low pH. When they are present in large quantities, they become poisonous. The chemical analysis of inputindustrialwastewaterrevealsthatmetalssuchasleadispresentinrangeof1.2552mg/l,zinc-2.305 mg/l copper - 3.54 20mg/l; cobalt- 2.15 mg/l; manganese- 3.705 mg/l; nickel- 2.505 mg/l; iron-13.4145mg/l in the bioreactor.

In A, lead levels decreased to 0.1470 and 0.3648 mg/l (average of AI, AII, AIII). Lead concentration decreased to 0.1371 and 0.1064 mg/l in bioreactor B (average of BI, BII, and BIII), and to 0.1548 and 0.1179 mg/l in bioreactor C (average of CI, CII, and CIII) in 55 and 105 days, respectively.
Zinc content decreased to 0.9593 and 0.1129 mg/l in bioreactor A (mean of AI, AII, AIII), 0.8646 and 0.0434 mg/l in bioreactor B (mean of BI, BII, BIII), and 0.749 and 0.015 mg/l in bioreactor C (mean of CI, CII, CIII) 55 and 105 days, respectively.
copper concentration decreased to 0.291 and 0.094 mg/l in bioreactor A (mean of AI, AII,AIII), in bioreactor B (mean of BI, BII, BIII) copper concentration decreased to 0.0894and 0.118mg/l in bioreactor C (mean of CI, CII, CIII) copper concentration decreased to 0.881 and 0.113mg/lin 55 and 105 day respectively.
Cobalt concentration decreased to 0.0826 and 0.0681 mg/l in bioreactor A (mean of AI, AII, AIII), in bioreactor B (mean of BI, BII, BIII) cobalt concentration decreased to 0.487 and 0.060 mg/l, in bioreactor C (mean of CI, CII, CIII) concentration of cobalt decreased to 0.766 and 0.058mg/l, in 55 and 105days respectively.
Manganese concentration decreased to 1.778 and 0.044 mg/l, in bioreactor A (average of AI, AII, AIII), in bioreactor B (average of BI, BII, BIII) manganese concentration dropped to1.7017 and 0.044 mg/l, in bioreactor C (average of CI, CII, CIII) manganese concentration decreased to 1.482 and 0.0376mg/l in 55 and 105 days respectively.
Nickel concentration dropped to 1.323 and 1.250 mg/l in bioreactor A (average of AI, AII, AIII), in bioreactor B (average of BI, BII, BIII) nickel concentration dropped to 2.644 and 1.603mg/l, in bioreactor C (average of CI, CII, CIII) nickel concentration dropped to 2.147 and 0.872mg/l, in 50 and 100 days respectively
Iron concentration dropped to 6.868 and 1.648 mg/l in bioreactor A (average of AI, AII, AIII), in bioreactor B (average of BI, BII, BIII) iron concentration dropped to 7.505 and 1.399mg/l, in bioreactor C(average of CI,CII,CIII)iron concentration dropped to 6.858 and 1.388mg/l, in 55 and 105days respectively.

CONCLUSION AND RECOMMENDATIONS

The legacy of our industrial past is with us in many developed and developing countries in relation to the health and wealth of the environment. Industrial waste water continues to be a significant global water pollution issue .Industrial processes in particular metal processing industry, pesticides, rubber and plastic, lumber and wood products as well as municipal waste water collection, almost always result in wastewater that requires further treatment before being discharged.
Fostering greater awareness and ecological protection as biotechnologies enter the mainstream, their advantages are assessed in comparison to those of competing technologies and in light of commercial considerations. This test has been passed, and waste water treatment using inexpensive adsorbents is now highly recommended for the rehabilitation of contaminated water and soil. The technology for treating anaerobic wastewater has advanced over decades of research and use, making it competitive. Anaerobic treatments outperform several options in terms of cost efficiency and sustainability. The energy-saving component of the treatment technique, specifically the decision to employ biogas produced by organic substrates rather than fossil fuels for the treatment, was a major motivating force. Microbial biomass has become a viable option in this project for creating wastewater treatment systems that are both affordable and environmentally benign.
The most important factor for which this treatment technology is accepted in the industries is due to its reduction in space requirementupto90%. Chemical treatment processes for pH reduction leads to the creation of unstable secondary wastes which requires further disposal, but in bioreactors there is 90%, reduction in sludge (waste product).
Industrial waste water with low pH was collected from common drainage from number of industries containing acidity and toxic metals. All the three sets of bioreactors were allowed for bacterial culture by moisturising the substrate with whey and after formation of black film (SRBs culture) industrial wastewater was installed in them for the treatment processes. These substrates were locally available which included manures and fruit wastes rich in carbon. Only low maintenance would be required. This technology opposes the costly chemical treatment technology i.e. using alkaline chemicals which presents a number of limitations.
The in situ treatment concept may be useful in the relatively small systems or in defined parts of larger systems where it is possible to monitor water chemistry and thereby govern the process properly.
The feasibility of this technology for industrial wastewater is yet to be developed in India, but it offers the promise of a compact economical treatment technology suitable for Industrial wastewater from different industrial units with toxic metal contaminants. Its applicability to other contaminated water is

investigated by potential researchers and will allow further investigation of this new technology at treatment sites and with other contaminated water of great concern to society.
This work proposes that in addition to examining the subject through the eyes of specialist adopta system approach and work on developing an integrated biological system with enhanced effluent treatment capacity. Thus this requires an interdisciplinary approach with emphasis perhaps more on empirical trial and error experimentation rather than theory. It is clear that industry still lacks knowledge of the extent to which such inter disciplinary treatment systems offer useful opportunities.
The discipline of industrial effluent treatment has just recently become familiar with microbiology. More effort will undoubtedly pay off. It is important to persuade business and academic organisations to invest more money in this effort. As is customary in the case of developing technologies, industry should not undervalue the time and effort required to establish trustworthy and useful systems.
The research described in this study provides the foundation of the development of a new treatment technology for industrial waste water with similar characteristics in India. In sight into the mechanism of pollutants removals was gained, but development of fundamental model of mechanism of pollutant removal was beyond the scope of this study.

RECOMMENDATIONS

The present research carried out provides quantitative information on the bioreactors to develop a strategy for improveing the removal of toxicants from industrial waste water treatment technology.
The in situ treatment concept is successful under laboratory scale study where it is possible to monitor water chemistry and there by govern the process properly.
Thus this concept presently may be useful in relatively small systems or defined parts of the larger system where the water chemistry can be properly governed.
To further deploy these self-sustaining environmentally friendly biotechnologies in industrial wastewater treatment, cooperation between the industrial community and governmental agencies and academic research institutions must be established. Our research aims to clarify the methods for controlling the environmental damage brought on by water contamination on this planet.

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