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Comparative Study of Heavy Metals Removal By Using Natural Adsorbents

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Abstract: This project deals with the comparative study of heavy metal removal including lead, chromium and copper by using low cost adsorbents such as bamboo husk, syzygumcumini seed, theobroma cacao pod and borassusflabellifier peel. One useful solution for the elimination of heavy metals from the environment is the treatment of industrial effluent streams (wastewater) using an efficient method, adsorption, before being discharged into the aquatic systems. Adsorption is an efficient and effective method for the removal of lead, chromium and copper when a suitable low cost adsorbent is identified. The development of low cost adsorbent is essential for the benefit of the common people. At present, batch experiments and column tests are conducted to determine the amount of heavy metal removal from the water bodies. In this project waste water after being passed through the three sets of processes like sedimentation, filtration, and adsorption column by using adsorbent such as bamboo husk, syzygumcumini seed, theobroma cacao pod and borassusflabellifier peel. In order to determine the efficiency of adsorbents for the removal of various heavy metals.

Keywords: syzygumcumini seed, theobroma cacao pod, borassusflabellifier peel, syzygumcumini, biosorption

1. Introduction

Developmental activities such as construction, transportation and manufacturing not only deplete the natural resources but also produce large amount of wastes that leads to pollution of air, water, soil, and oceans; global warming and acid rains. Untreated or improperly treated waste is a major cause of pollution of rivers and environmental degradation causing ill health and loss of crop productivity. In this lesson you will study about the major causes of pollution, their effects on our environment and the various measures that can be taken to control such pollutions.

Heavy metal ions are usually discharged into the stream or rivers as a waste product from the industries such as textile dyeing, leather, tanning, electroplating, fertilizers, metallurgical, metal plating, etc. The industrial effluents contain different derivatives of heavy metals such as Cd, Pb, Ni, Cr, As, Cu, Fe etc. The heavy metal from polluted stream can be easily enters into the surrounding soil, surface water, ground water etc. which are continuously discharged into the ecosystem and produce significant toxic impact.

The heavy metals hazardous to humans include lead, mercury, cadmium, arsenic, copper, zinc, and chromium. Such metals are found naturally in the soil in trace amounts, which pose few problems. When concentrated in particular areas, however, they present a serious danger. Arsenic and cadmium, for instance, can cause cancer. Mercury can cause mutations and genetic damage, while copper, lead, and mercury can cause brain and bone damage. Next section presents the harmful effects to the four heavy metals that are prevalent in the environment.

It also has a d v e r s e effect on human skin, kidney and liver. It causes respiratory problems, alteration of genetic material, lung cancer, and bronchitis.

Over the last few decades, several methods have been devised for the treatment and removal of heavy metals. Numerous industries (e.g., electroplating, metal finishing operations, electronic –circuit production, steel and non-ferrous processes and fine chemical and pharmaceutical production) discharge a variety of toxic metals into the environment. For several years now, it is mandatory that industry is required to remove metal pollutants from liquid discharges. The commonly used procedures for removing metal ions from aqueous streams include chemical precipitation, lime coagulation, ion exchange, reverse osmosis and solvent extraction.

1.2 Adsorbents

There are many types of adsorbents; Earth's forests and plants, ocean and freshwater plankton, algae and fish, all living creatures, that including animals are all "biomass/ adsorbents". The renewable character of biomass that grows, fuelled directly or indirectly by sunshine, makes it an inexhaustible pool of chemicals of all kinds. Based on metal binding capacities of various biological materials.Biosorption can be defined as the ability of biological materials to accumulate heavy metals from wastewater through metabolically mediated or physico-chemical pathways of uptake.

1.3Theobroma cacao

Theobroma cacao is the taxonomic classification for the plant also called the cacao tree and the cocoa tree, which is a small (4–8 m tall) evergreen tree in the family Malvaceae, native to the deep tropical regions of Central and South America. Its seeds, cocoa beans, are used to make cocoa mass, cocoa powder, confectionery and chocolate.

1.4 Borassus flabellifier

Borassus flabellifer, commonly known as doub palm, palmyra palm, tala palm, toddy palm or wine palm, is native to the Indian subcontinent and Southeast.Borassusflabellifer is a robust tree and can reach a height of 30 metres (98 ft). The trunk is grey, robust and ringed with leaf scars; old leaves remain attached to the trunk for several years before falling cleanly. The fruit measures 10 cm (3.9 in) to 18 cm (7.1 in) in diameter, has a black husk, and is borne in clusters. The top portion of the fruit must be cut off to reveal the sweet jelly seed sockets, translucent pale-white, similar to that of the lychee but with a milder flavor and no pit. The sweet jelly seed sockets occur in combinations of two, three or four seeds inside the fruit. The jelly part of the fruit is covered with a thin, yellowish-brown skin. These are known to contain watery fluid inside the fleshy white body.

1.5 Bamboo

The bamboos are evergreen perennial floweringplants inthe subfamily Bambusoideae of the grass family Poaceae. In bamboo, as in other grasses, the in ternodal regions of the stem are usually hollow and the vascular bundles in the cross section are scattered throughout the stem instead of in a cylindrical arrangement. Bamboos include some of the fastest-growing plants in the world, due to a unique rhizome-dependent system. Certain species of bamboo can grow 91 cm (3 ft) within a 24-hour period, at a rate of almost 4 cm (1.5 in) an hour (a growth around 1 mm every 90 seconds, or one inch every 40 minutes).[5] Giant bamboos are the largest members of the grass family.

1.6 Syzygiumcumini

Syzygiumcumini, known as jambul, jambolan, jamblang or jamun, is an evergreen tropical tree in the flowering plant family Myrtaceae. It is native to the Indian Subcontinent, adjoining regions of Southeast Asia, China and Queensland.[1] The name of the fruit is sometimes mistranslated as blackberry, which is a different fruit in an unrelated family. A slow growing species, it can reach heights of up to 30 m and can live more than 100 years. Its dense foliage provides shade and is grown just for its ornamental value. At the base of the tree, the bark is rough and dark grey, becoming lighter grey and smoother higher up. The wood is water resistant.

2. Methodology

2.1 Materials

The materials used in this study were purchased from nearby village (Kunnamkulam). The carica papaya leafs,seeds and trunk were used for preparation of adsorbents.

2.1.1 Industrial Waste Water Sample

Industrial Waste water is collected from 3 places in kerala. Sample 1 collected from, texile industry – Renus garments from athhani – thrissur, and sample NO 2 collected from tannery industry Rivoli international private limted from Calicut. And sample NO 3 collected from pesticide industry Kisan excel private limited from calicut . The wastewater characteristics were tested before the commencement of the project and the various characteristics like TDS, SS, DO, COD, BOD, turbidity, hardness, alkalinity, chloride, sulphate, iron, Ph and heavy metal content were tested and were compared with the limit.

Figure 1: Industrial Waste Water Sample

2.1.2Filtration Unit

The filtration tank is constructed with dimension of 30cm x 30cm x 45cm. Filtration tank consist of 3 layers of filter media. Top layer is charcoal, which is available from the local market. The next layer is sand, which should be of uniform grain size to make sure that the pores between grains are the same size so that the filter's efficiency should be equal over the bed.Gravel support is provided to support the sand bed and to permit uniform drainage of the overlying sand. This layer allows water to drain freely from the sand bed while preventing sand from escaping to the outlet tank. To accomplish both purposes, the gravel support must be graded, with finer material at the top and coarser material at the bottom.. The bottom most layer of the filter is filled with 20mm gravels with a filtration depth of 15cm. The second layer is filled with 15cm gravels with a depth of 10cm.

Figure 2: Filtration Set Up

2.2 Methods

2.2.1 Preparation of natural absorbent- Theobroma cacao pod husk

Theobroma cacao were obtained from the local market. The fruits were sliced open using a clean stainless steel laboratory knife. The pod of cocao were washed severally with water, sun-dried for a week, sorted to remove bad pod piece, packed in an air tight container. 150g of the crushed pod of cocao were then sieved and packed. The finer particles were then used as the absorbent.

2.2.2Preparation of natural absorbent-Borassus flabellifier

Borassus flabellifier fruit were obtained from the local market. The fruits were sliced open using a clean stainless steel laboratory knife. Peel of Borassus flabellifier fruit were washed severally with water, sun-dried for a week, sorted to remove bad piece , packed in an air tight container. 150g of the crushed Borassus flabellifier fruit peel were then sieved and packed. The finer particles were then used as the absorbent.

2.2.3 Preparation of natural absorbent-Bamboo

The bamboos are evergreen perennial floweringplants inthe subfamily Bambusoideae of the grass family.

2.2.4 Preparation of natural absorbent-Syzygiumcumini

Syzygiumcumini,were obtained from the local market. The fruits were sliced open using a clean stainless steel laboratory knife. The seed were washed severally with water, sun-dried for a week, sorted to remove bad ones , packed in an air tight container. 150g of the crushed seed were then sieved and packed. The finer particles were then used as the absorbent.

2.2.5 Adsorption Using Cocao Pod Husk

The column apparatus is filled with cocoa pod husk of 45 cm height. At first 1000 ml of distilled water were added into the apparatus and kept for 30 minutes with the outlet closed. After 15 minutes 950 ml water is collected when the outlet was opened. The waste water is kept in the overhead tank and then allowed to flow into column apparatus through inlet by drop by drop. After keeping for a retention period of 30 minutes with the outlet closed, then water were collected from the collection tank. The removal efficiency was determined. Also the test is conducted by varying retention time of 60 and 90 minutes. Similarly the above procedure was repeated with varying height of adsorbent of 15 and 30 cm. Then the same procedure is repeated by using borassus flabellifier,bamboo and syzygiumcumini and also its combination of all these 3 adsorbents in the column apparatus.

Figure 3: Adsorption Using Cocao Pod Husk

2.2.6 Adsorption Using Combination Of All Adsorbents

The removal efficiency was tested using combination of cocao pod husk, borassusflabllifier, bamboo husk and syzygiumcumini.The column apparatus is filled with cocao pod husk, borassusflabllifier, bamboo husk and syzygiumcumini of height 10 cm each. At first 1000 ml of distilled water were added into the apparatus and kept for 30 minutes with the outlet closed. After 15 minutes 950 ml water is collected when the outlet was opened. The waste water is kept in the overhead tank and then allowed to flow into column apparatus through inlet by drop by drop. After keeping for a retention period of 30 minutes with the outlet closed, then water were collected from the collection tank. The removal efficiency was determined. Also the test is conducted by varying retention time of 60 and 90 minutes. Similarly the above procedure was repeated with varying height of adsorbent of 10 and 15 cm each

3. Results and Discussions

3.1 Parameters Before And After Filtration

The industrial wastewater characteristics were tested before the commencement of the project and the initial characteristics like pH, BOD, dissolved oxygen, total suspended solids, total dissolved solids, alkalinity, chlorides, Dissolved oxygen, iron, colour, turbidity, heavy metal content etc. were tested and were compared with the irrigation water limit. The limits were not satisfactory but the water can be easily purified through simple methods of purification. Later the industrial waste water after being passed through the three sets of processes; sedimentation, filtration and adsorption column.

Table 1: Parameters Before And After Filtration

Parameters	Value Of Parameters Before Filtration			Value Of Parameters After Filtration			Permissible Limit (Irrigation)
	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3	
pH	8.4	8	6	6.5	6.8	6.7	6.5 - 8.5
TOTAL HARDNESS (Mg/L)	540	420	900	510	390	852	<100
DO(Mg/L)	0	0	0	0.5	1	1.5	<150
BOD (Mg/L)	668	245	3000	456	220	2340	<100
TURBIDITY (NTU)	70	55	380	68	50	325	<10
TDS (Mg/L)	2700	2350	3444	2555	2200	3030	<2000
TSS (Mg/L)	156	222	875	117	210	162	<25
ALKALINITY (Mg/L)	220	252	232	112	248	220	<1
Cr (MgLl)	0.25	-	-	0.25	-	-	<30
Pb (Mg/L)	-	0.32	-	-	0.32	-	<2
Cu (Mg/L)	-	-	2	-	-	2	<30

3.2 Cacao Pod HuskAs Adsorbent (Varying Depth)

From the table, it can be concluded that, the value of parameters has been decreased after adsorption with cocoa pod husk .As the depth of adsorbent increases the value of the parameters decreases. The BOD removal efficiency for cocoa pod husk obtained 45%,63% and 82% for sample 1, 2 ,3 ,respectively The optimum pH is obtained for sample 1 is 7.2 and sample 2 is 7.3 and sample 3 is 7.5. The turbidity is reduced from 70 NTU to 42 NTU for sample no 1 and 55 NTU to 42 NTU for sample no 2 and 380 NTU to 98 NTU for sample no 3 at a depth of 45cm. The maximum removal efficiency is obtained at 45 cm of depth of adsorbent.

Table 2: Cacao Pod Husk As Adsorbent

SL. No	Parameter	Sample 1			Sample 2			Sample 3		
		15 cm	30 cm	45 cm	15 cm	30 cm	45 cm	15 cm	30 cm	45 cm
1	Ph	6.6	6.8	7.2	6.9	7	7.3	6.8	7.2	7.5
2	Turbidity (NTU)	62	58	53	48	45	42	220	145	98
3	Total dissolved solids	2500	2422	2020	2110	2018	1995	3010	2558	2050
4	Alkalinity (mg/l)	110	95	80	240	225	215	210	190	180

5	Total hardness (as CaCO3)	600	480	460	380	370	320	210	200	190
6	Biochemical Oxygen Demand	450	445	430	210	200	190	2300	2100	2000
7	Dissolved Oxygen	0.7	.75	0.8	1	1.2	1.3	1.1	1.5	16
8	Total Suspended Solids	110	105	100	208	206	200	200	190	180
9	Chromium (mg/l)	0.23	0.22	0.21						
10	Lead (mg/l)				0.3	0.3	0.3			
11	Copper (mg/l)							2	1.9	1.8

3.3 Borassus Flabellifier Fruit Peel PowderAs Adsorbent (Varying Depth)

It can be concluded that, the value of parameters has been decreased after adsorption with borassusflabellifier .As the depth of adsorbent increases the value of the parameters decreases. The BOD removal efficiency for borassusflabellifier husk obtained 53%,74% and 49% for sample 1, 2 ,3 ,respectively, the optimum pH is obtained for sample 1 is 7.0 and sample 2 is 7.1 and sample 3 is 7.3. The turbidity is reduced from 70 NTU to 61 NTU for sample no 1 and 55 NTU to 50 NTU for sample no 2 and 380 NTU to 110 NTU for sample no 3 at a depth of 45cm. The maximum removal efficiency is obtained at 45 cm of depth of adsorbent.

Table 3: Borassus Flabellifier Fruit Peel PowderAs Adsorbent

SL. No	**Parameter**	**Sample 1**			**Sample 2**			**Sample 3**		
		15 cm	**30 cm**	**45 cm**	**15 cm**	**30 cm**	**45 cm**	**15 cm**	**30 cm**	**45 cm**
1	Ph	6.8	6.9	7	6.6	7.3	7.1	6.9	7.1	7.2
2	Turbidity (NTU)	90	80	61	88	73	50	245	200	110
3	Total dissolved solids	2150	2072	1670	1760	1668	1645	2660	2208	1700
4	Alkalinity (mg/l)	115	98	75	225	218	200	200	195	175
5	Total hardness (as CaCO3)	550	520	500	420	400	390	640	590	310
6	Biochemical Oxygen Demand	210	190	185	225	218	200	2100	1990	1800
7	Dissolved Oxygen	6.5	6.5	6.6	6.8	7	7	6.9	7.3	7.1
8	Total Suspended Solids	100	95	90	198	196	190	190	180	170
9	Chromium (mg/l)	0.24	0.24	0.24						
10	Lead (mg/l)				0.31	0.31	0.3			

11	Copper (mg/l)							2.3	2.1	2

3.4 Borassus Bamboo Husk As Adsorbent (Varying Depth)

It can be concluded that, the value of parameters has been decreased after adsorption with bamboo husk .As the depth of adsorbent increases the value of the parameters decreases. The BOD removal efficiency for cocoa pod husk obtained 61%,83% and 71% for sample 1, 2 ,3 ,respectively The optimum pH is obtained for sample 1 is 7.1 and sample 2 is 7.2 and sample 3 is 7.3. The turbidity is reduced from 70 NTU to 54 NTU for sample no 1 and 55 NTU to 44 NTU for sample no 2 and 380 NTU to 95 NTU for sample no 3 at a depth of 45cm. The maximum removal efficiency is obtained at 45 cm of depth of adsorbent

Table 4: Bamboo HuskAs Adsorbent

SL. No	**Parameter**	**Sample 1**			**Sample 2**			**Sample 3**		
		15 cm	**30 cm**	**45 cm**	**15 cm**	**30 cm**	**45 cm**	**15 cm**	**30 cm**	**45 cm**
1	Ph	6.7	7	7.1	6.4	7.1	7.2	7	7.3	7.3
2	Turbidity (NTU)	112	98	54	87	79	44	117	105	95
3	TDS	2112	2034	1632	1722	1630	1607	2622	2170	1662
4	Alkalinity (mg/l)	200	165	150	230	215	200	220	210	180
5	Total hardness (as CaCO3)	420	385	228	580	410	315	375	285	110
6	Biochemical Oxygen Demand	320	315	290	265	250	230	2500	2225	2150
7	Dissolved Oxygen	5.8	5.85	5.9	6.1	6.3	6.4	6.2	6.6	6.7
8	Total Suspended Solids	125	120	115	223	221	215	215	205	195
9	Chromium (mg/l)	0.24	0.23	0.22						
10	Lead (mg/l)				0.33	0.32	0.32			
11	Copper (mg/l)							2.2	2.1	2

3.5 SyzygiumCumini Seed PowderAs Adsorbent (Varying Depth)

It can be concluded that, the value of parameters has been decreased after adsorption withSyzygiumcumini. As the depth of adsorbent increases the value of the parameters decreases. The BOD removal efficiency for cocoa pod husk obtained 48%,83% and 35% for sample 1, 2 ,3 ,respectively The optimum pH is obtained for sample 1 is 7.2 and sample 2 is 7.0 and sample 3 is 7.4. The turbidity is reduced from 70 NTU to 63 NTU for sample no 1 and 55 NTU to 51 NTU for sample no 2 and 380 NTU to 111 NTU for sample no 3 at a depth of 45cm. The maximum removal efficiency is obtained at 45 cm of depth of adsorbent.

Table 5: SyzygiumCumini Seed PowderAs Adsorbent

SL. No	Parameter	Sample 1			Sample 2			Sample 3		
		15 cm	30 cm	45 cm	15 cm	30 cm	45 cm	15 cm	30 cm	45 cm
1	Ph	6.9	7.2	7.2	6.8	7.2	7	7.2	7	7.4
2	Turbidity (NTU)	129	114	63	206	174	51	112	95	111
3	TDS	2177	2099	1697	1787	1695	1672	2687	2235	1727
4	Alkalinity (mg/l)	180	160	130	175	155	120	150	125	110
5	Total hardness (as CaCO3)	570	380	280	150	135	120	550	460	375
6	Biochemical Oxygen Demand	540	510	490	325	305	290	2225	2200	1995
7	Dissolved Oxygen	7.3	7.3	7.4	7.6	7.8	7.9	7.7	8.1	8.2
8	Total Suspended Solids	155	150	145	253	251	245	245	235	225
9	Chromium (mg/l)	0.24	0.23	0.23						
10	Lead (mg/l)				0.31	0.3	0.29			
11	Copper (mg/l)							2.2	2	1.8

3.6 Combination of All Adsorbent (Varying Depth)

Table 6 shows combination of cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini as adsorbent with varying depth. From the table it can be concluded that, the value of parameters has been decreased after adsorption. As the depth of adsorbent increases the value of the parameters decreases. . The BOD removal efficiency for cocoa pod husk obtained 88%,83% and 84% for sample 1, 2 ,3 ,respectively The optimum pH is obtained for sample 1 is 7.0 and sample 2 is 7.3 and sample 3 is 7.1. The turbidity is reduced from 70 NTU to 40 NTU for sample no 1 and 55 NTU to 47 NTU for sample no 2 and 380 NTU to 36 NTU for sample no 3 at a depth of 45cm. The maximum removal efficiency is obtained at 45 cm of depth of adsorbent.

Table 6: Combination of All Adsorbent

SL. No	Parameter	Sample 1			Sample 2			Sample 3		
		15 cm	30 cm	45 cm	15 cm	30 cm	45 cm	15 cm	30 cm	45 cm
1	Ph	7	7.3	7	7.2	7.5	7.3	7.3	7.4	7.1
2	Turbidity (NTU)	107	53	40	92	70	47	89	66	36
3	TDS	2098	2020	1618	1708	1616	1593	2608	2156	1648
4	Alkalinity (mg/l)	100	75	60	210	195	180	125	115	100

5	Total hardness (as CaCO3)	310	283	225	265	250	225	110	90	75
6	Biochemical Oxygen Demand	180	173	150	185	164	135	2115	2008	1985
7	Dissolved Oxygen	7.7	7.75	7.8	8	8.2	8.3	8.1	8.5	8.6
8	T SS	88	83	78	186	184	178	178	168	158
9	Chromium (mg/l)	0.25	0.23	0.22						
10	Lead (mg/l)				0.32	0.31	0.28			
11	Copper (mg/l)							1.9	1.7	1.6

3.7 Optimum Time

The optimum time is found out from the optimum depth. The optimum depth that has been obtained is 45cm. The optimum depth was obtained by conducting tests under varying depths of 15cm, 30cm and 45cm. The maximum efficiency is obtained at 90minutes.

3.7.1 Cacao Pod HuskAs Adsorbent (Varying Optimum Time)

Table 7 shows cocoa pod husk as Adsorbent with Varying Retention Period. From the table it can be concluded that, the value of parameters has been decreased after adsorption withcocao pod husk . As the retention time increases the value of the parameters decreases. The BOD removal efficiency is obtained 84 % and 85% respectively. The optimum pH is obtained as 7.5 for sample no 1 and 3 , and 7.6 for sample no 2. The turbidity is reduced from 70 NTU to 9 NTU for sample no 1 and 55NTU to 12NTU for sample no 2 and 380NTU to 11 NTU for sample no 3 at a retention time of 90min.The removal efficiency of hardness is obtained as 89%. Compared with the initial value of 2700 mg/l, the addition of adsorbents in wastewater made the TDS value down to 690 mg/l for sample no 1 and 431 mg/l for sample no 2 and 300 mg/l for sample no 3. The maximum removal efficiency is obtained at 90minutes of time.

Table 7: Cocoa Pod Husk As Adsorbent With Varying Retention Period

SL. No	**Parameter**	**Sample 1**			**Sample 2**			**Sample 3**		
		30 min	**60 min**	**90 min**	**30 min**	**60 min**	**90 min**	**30 min**	**60 min**	**90 min**
1	Ph	7	7.3	7.5	7.2	7.4	7.6	7.1	7.4	7.5
2	Turbidity (NTU)	39	26	9	42	35	12	97	55	11
3	TDS	801	780	690	630	520	431	540	440	300
5	Total hardness (as CaCO3)	201	183	102	222	190	105	320	277	270
6	Biochemical Oxygen Demand	623	519	461	510	467	330	720	630	543
7	Dissolved Oxygen	5.8	6.2	7.6	6.1	7.4	7.8	7	7.6	8

8	T SS	143	128	103	155	138	122	123	118	100
9	Chromium (mg/l)	0.22	0.21	0.21						
10	Lead (mg/l)				0.3	0.3	0.3			
11	Copper (mg/l)							1.5	0.5	0.3

3.7.2 Borassus Flabellifier Fruit Peel PowderAs Adsorbent (Varying Optimum Time)

From the table it can be concluded that, the value of parameters has been decreased after adsorption with Borassusflablifier. As the retention time increases the value of the parameters decreases. The BOD removal efficiency is obtained and 88.7% respectively. The optimum pH is obtained as 7.7. The turbidity is reduced from 70 NTU to 21 NTU for first sample and 55 NTU to 25NTU for second sample and 380NTU to 23 NTU for third sample at a retention time of 90min.

Table 8: Borassus Flabellifier Fruit Peel PowderAs Adsorbent With Varying Retention Period

SL. No	**Parameter**	**Sample 1**			**Sample 2**			**Sample 3**		
		15 cm	**30 cm**	**45 cm**	**15 cm**	**30 cm**	**45 cm**	**15 cm**	**30 cm**	**45 cm**
1	Ph	6.8	6.8	7	6.6	7.3	7.1	6.9	7.1	7.4
2	Turbidity (NTU)	51	22	21	54	27	24	96	75	23
3	TDS	824	803	713	653	543	454	563	463	323
4	Alkalinity (mg/l)	122	107	92	109	96	82	92	87	75
5	Total hardness (as CaCO3)	212	194	113	233	201	116	331	288	281
6	Biochemical Oxygen Demand	635	531	473	522	479	342	732	642	555
7	Dissolved Oxygen	6	6.4	7.8	6.3	7.6	8	7.2	7.8	8.2
8	T SS	154	139	114	166	149	133	134	129	111
9	Chromium (mg/l)	0.24	0.24	0.24						
10	Lead (mg/l)				0.31	0.31	0.3			
11	Copper (mg/l)							1.2	1	0.9

3.7.3 Bamboo HuskAs Adsorbent (Varying Optimum Time)

Table 4.11 shows Bmboo husk as Adsorbent with Varying Retention Period. From the table it can be concluded that, the value of parameters has been decreased after adsorption. The BOD removal efficiency is 77.5%. The optimum pH is obtained as 7.3. The removal efficiency of conductivity is obtained as 68.5%. The removal efficiency of chloride and turbidity is obtained as 62.3% and 83.7%. The maximum removal efficiency is obtained at 90minutes of time.

Table 9: Bamboo HuskAs Adsorbent With Varying Retention Period

SL. No	Parameter	Sample 1			Sample 2			Sample 3		
		15 cm	30 cm	45 cm	15 cm	30 cm	45 cm	15 cm	30 cm	45 cm
1	Ph	6.7	7	7.1	6.5	7.1	7.2	7	7.3	7.3
2	Turbidity (NTU)	20	7	18	23	16	7	78	36	8
3	TDS	596	575	485	425	315	226	335	235	95
4	Alkalinity (mg/l)	95	80	65	82	69	55	65	60	48
5	Total hardness (as CaCO3)	189	171	90	210	178	93	308	265	258
6	Biochemical Oxygen Demand	611	507	449	468	455	318	708	618	531
7	Dissolved Oxygen	6.4	6.8	8.2	6.7	8	8.4	7.6	8.2	8.6
8	T SS	159	144	119	171	154	138	139	134	116
9	Chromium (mg/l)	0.23	0.23	0.23						
10	Lead (mg/l)				0.3	0.31	0.28			
11	Copper (mg/l)							1	0.95	0.8

3.7.4 Syzygiumcumini As Adsorbent (Varying Optimum Time)

From the table it can be concluded that, the value of parameters has been decreased after adsorption. The BOD removal efficiency is obtained 72.5 %. The optimum pH is obtained as 7.5. The removal efficiency of turbidity is obtained as and 83.7%. The maximum removal efficiency is obtained at 90minutes of time.

Table 10: SyzygiumcuminiAs Adsorbent With Varying Retention Period

SL. No	Parameter	Sample 1			Sample 2			Sample 3		
		15 cm	30 cm	45 cm	15 cm	30 cm	45 cm	15 cm	30 cm	45 cm
1	Ph	7	7.2	7.2	6.8	7.2	7	7.2	7	7.5
2	Turbidity (NTU)	40	11	10	43	16	13	85	64	12
3	TDS	620	599	509	449	399	250	359	259	119
4	Alkalinity (mg/l)	117	102	87	104	91	77	87	82	70
5	Total hardness (as CaCO3)	176	158	77	197	165	80	295	252	245

6	Biochemical Oxygen Demand	509	405	347	396	353	216	606	516	429
7	Dissolved Oxygen	5.9	6.3	7.7	6.2	7.5	7.9	7.1	7.7	8.1
8	T SS	146	131	106	158	141	125	126	121	103
9	Chromium (mg/l)	0.24	0.23	0.23						
10	Lead (mg/l)				0.31	0.3	0.29			
11	Copper (mg/l)							1.4	1	0.6

3.7.5Combination of AllAdsorbent (Varying Optimum Time)

From the table it can be concluded that, the value of parameters has been decreased after adsorption. As the retention time increases the value of the parameters decreases. The BOD removal efficiency is obtained 98.5%. The maximum removal efficiency is obtained at 90minutes of time and optimum pH is 7.4 for sample no 1 and 7.5 for sample no 2 and 7.8 for sample no 3.

Table 11: Combination of All Adsorbent With Varying Retention Period

SL. No	**Parameter**	**Sample 1**			**Sample 2**			**Sample 3**		
		30 min	**60 min**	**90 min**	**30 min**	**60 min**	**90 min**	**30 min**	**60 min**	**90 min**
1	Ph	7	7.3	7.4	7.2	7.5	7.5	7.3	7.4	7.8
2	Turbidity (NTU)	11	24	12	14	13	6	20	17	9
3	TDS	396	375	285	225	115	26	135	130	122
4	Alkalinity (mg/l)	86	71	56	73	60	46	56	51	39
5	Total hardness (as CaCO3)	164	146	65	185	153	68	283	240	233
6	Biochemical Oxygen Demand	98	92	80	192	97	83	112	85	75
7	Dissolved Oxygen	6.2	6.6	8	6.5	7.8	8.2	7.4	8	8.4
8	T SS	131	116	91	143	126	110	111	106	88
9	Chromium (mg/l)	0.01	0.05	0.05						
10	Lead (mg/l)				0.1	0.1	0.05			
11	Copper (mg/l)							0.1	0.2	0.15

3.8 Percentage Reduction In Parameters After Adsorption

Maximum removal efficiency is obtained at 45 cm of depth by using combination of adsorbent.

Table 12: Percentage ReductionIn Parameters

Parameter	Efficiency		
	Sample 1	**Sample 2**	**Sample 3**
Turbidity	84%	78%	96%
TDS	40%	52%	56%
Alkalinity	72%	61%	57%
Hardness	58%	48%	91%
BOD	77%	44%	58%
DO	87%	84%	86%
TSS	5%	19%	81%
Chromium	16%		
Lead		12%	
Copper			20%

The maximum percentage reduction is obtained at an adsorption depth of 45cm and retention time of 90 minutes. Maximum removal efficiency is obtained at 90 minutes of retention time by using combination of adsorbent.

Table 13: Percentage Reduction In Parameters

Parameter	Efficiency		
	Sample 1	**Sample 2**	**Sample 3**
Turbidity	85%	89%	97%
TDS	89%	98%	96%
Alkalinity	74%	81%	83%
Hardness	88%	83%	74%
BOD	88%	66%	97%
DO	87%	84%	86%
TSS	41%	50%	90%
Chromium	80%		
Lead		84%	
Copper			92%

4. Conclusions

Adsorption is one of the fundamental process in physiochemical treatment of wastewaters. The advantage of adsorption method comparing with other system is that, it needs lower land area requirements, lower sensitivity to diurnal flow and concentration variations and to toxic substances, potential for significant heavy metal removal, greater flexibility in design and operation and organic waste removal. This study has successfully revealed that the treatment with cacao pod husk,Borassus flabellifier fruit peel powder,bamboo husk and Syzygiumcumini are efficient in removing chemical and biological parameters in the wastewater. The optimum pH is 7.5, 7.7 , 7.3 and 7 respectively for cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini and the optimum adsorbent depth and optimum time is found to be 45cm and 90min respectively. The reduction of BOD for the industrial wastewater is 88%, 66% and 97% for sample no 1,2,3 collected from different industries. , reduction in Turbidity is 85%, 84%, and 97% f respectively for all 3 samples. and reduction in TDS is 89% , 98% and 96% byadsorption using combination of cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini. Reduction in hardness is 88%, 83% and 74% for sample no 1,2,3 respectively.

This study has successfully revealed that the treatment with the combination of cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini can effectively removing the heavy metal content . in sample no 1 collected from textile industry – Renus garments from athhani – thrissurcontain 0.25 mg/l of chromium . during the treatment with combination of cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini the chromium content in the sample is reduced to 0.05. similar , sample no 2 collected from tannery industry Rivoli international private limited from Calicut contain 0.32 mg/l of lead reduced to 0.05 mg/l during the treatment. And sample no 3 collected from pesticide industry Kisan excel private limited from Calicut contain 2 mg/l of copper is reduced to 0.15 mg/l during the treatment with combination of cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini at 45cm depth and 90 minutes of retention period.

So it can be co0ncluded that 80% of chromium removal and 84% of lead removal and 92% of copper removal is obtained by using the combination of cacao pod husk,Borassus flabellifier fruit peel powder, bamboo husk and Syzygiumcumini as absorbents.

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