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Cost-effective and Efficient Bio Waste Derived Adsorbents for Removal of Heavy Metals from Contaminated Water: A Review

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ABSTRACT

Over the last few decades, water contamination caused by heavy-metals has become a major threat to the environment all over the world. The present article is a review study. The reason for writing this review is to raise awareness about water pollution and its treatment. Paper discusses the effective elimination of metal ions (Pb^{2+}, Cu^{2+}, Cd^{2+} and Zn^{2+}) from wastewater, using eco-efficient Bio - adsorbents like waste-tea, Tamarind, Soybean, pomegranate, Rice-husk, Orange-peel and Coffee-Waste by bio-sorption method which is cost-efficient and a simple technique. Different parameters such as shaking-time, pH, temperature, and primary concentration for the sorption rate and percentage of elimination of toxic metals are working. FTIR, SEM, AAS, BET, EDS, XRD, TGA, and XPS used for characterization. The highest sorption capacities of different bio-adsorbents for selected heavy-metals were reviewed. The data fitted into Freundlich and Langmuir adsorption isotherm models. This review discusses the effective elimination of toxic metals from drinking water.
KEYWORDS: Bio-adsorbents, Bio waste, Toxic metals, Toxicity, Pollution.

INTRODUCTION

In all the universe, water is the main resource for the existence of all organisms and the progress of countries. Today, rapid industrialization, weather change, poisonous industrial waste, unplanned or random urbanization, and domestic effluents are increasingly polluting water, making access to clean and non-noxious drinking water a pressing problem [Y. Sheth, et. al, 2021; K. Harsha et. al,2019]. A very large amount of water is used by the industries and after being used, contaminated water is discharged into water bodies or drainage lands or rivers, reason severe perilous effects on aquatic fauna and vegetation. According to the WHO information, a minimum large than 0.8 million people die from diarrhea each year due to contaminated drinking water [WHO]. Many industrial wastewaters contain highly poisonous heavy metals and many dangerous chemicals. So, the removal of these highly poisonous transition metals from the contaminated water is a main step in the purification of the contaminated water. There are also some poisonous metals that are extremely poisonous in environment and these cannot be eliminated by biotic methods like other biological wastes. [Ihsanullah et. al 2016; M.A. Barakat, 2011]. So, it's very important to remove heavy metals from polluted water before releasing them into drainage lands, rivers, and other water bodies.

Transition metals are notorious inorganic pollutants. Their atomic weight is between 63.5to 200.6 and has a density of extra than about 5 g/cm^3. All heavy metals are very toxic by nature and they have very good toxicity profiles, due to prolonged exposure to arsenic can cause several diseases such as integumentary system, hepatic systems, multiple organs or tissue systems in humans, central nervous, hepatic, and diarrhea [K.S. Mohammed Abdul et al., 2015]. Mercury can affect the immune system, central nervous system, and heart in addition the thyroid gland. It can also lead to a cognitive impairment such as blindness and deafness. Methyl mercury can cause a Minamata disease which is a neurological disease [P. Holmes et al., 2009]. Cadmium is responsible for severe health diseases like kidney damage, high blood pressure, testicular necrosis, Itai-Itai disease, lung damage, carcinogenicity and bone damage [Maribel S. Tizo, et al., 2018]. Pb is a very poisonous metal that has dangerous effects on the central nervous system, gastrointestinal, renal, immunological, cardiovascular, and reproductive [R. Naseem et al., 2001]. Excising the given acceptable limit chromium can cause serious diseases,

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Such as kidney failure, severe respiratory disease, and carcinogenicity in the gastrointestinal tract [P. Kumaret et al., 2019]. Beyond the given permissible limit lead concentration can induce various diseases, like as cardiovascular disease, lung cancer, pulmonary fibrosis, epigenetic effects, eye irritation, vomiting, lung and kidney damage, diarrhea, and pulmonary fibrosis [C.E. Borba et al., 2006]. As per studies, Zn is responsible for serious healthiness hazards like nausea, abdominal pain, metal fume fever (MFF), vomiting and prostate cancer [L.M. Plum et al., 2010]. In the same way, copper concentration exceeding the allowed limit can create serious health hazards like as renal toxicity, neurotoxicity, carcinogenicity, hepatotoxicity, Glucose-6-phosphate dehydrogenises deficiency, developmental toxicity and reproductive. Theorigins of some significant heavy metals as well as their health effects, maximum acceptable limits, anthropogenic Sources and health effects of various sources of these poisonous transition metals are shown in the 1 table under.

Table 1: Maximum acceptable limits, sources, and dangerous effects on health caused by several poisonous metals.

S.N.	poisonous Metals	Acceptable limits (mgL^{-1})		Sources	Toxicity and effect on health
		WHO	EPA		
	Lead	0.01	0.10	Smelting, batteries etc	Retardation of growth in children, nervous system, blood pressure, renal toxicity [A.L. Wani et al. , 2015]
	Copper	1.0	0.25	metal smelting	Diarrhoea, lung cancer, reproductive, renal toxicity [National Research Council (US)]
	Chromium	0.05	0.05 for Cr^{6+} 0.1 for Cr^{3+}	metal and leather Tanning	Hepatic, endocrine, Renal, cardiovascular, immune and digestive systems toxicity [S. Wilbur et al., 2012].
	Zinc	3.0	1.0	Galvanization and Pharmaceuticals	Anaemia, prostate cancer and abdominal pain[L.M. Plum et al., 2010]
	Mercury	0.01	0.05	Oil refining, drugs and thermometers etc.	Affects immune system, CNS, digestive system, lung damage, scleroderma, renal toxicity etc KM [Rice et al., 2014]
	Cadmium	0.003	0.005	Metal processing	Cancer, kidney lungs and skeletal damage [J. Godt et al., 2006]
	Arsenic	0.01	0.05	Burning of fossil fuels	Immunological, CNS, gastrointestinal, renal, and reproductive problems [M. Kuivenhoven Met al., 2021]
	Nickel	----	0.2	Battery industries, and zinc base casting	Lung cancer and gastrointestinal, -toxicity[G. Genchi, et al., 2020]

2.1 Common techniques for elimination of toxic transition metals

Some techniques such as membrane separation, co-precipitation, chemical precipitation, solvent extraction, electrochemical remediation, flocculation, complexation, oxidation/reduction, adsszorption, and ion exchange have been used to elimination poisonous heavy metal ions from industrial contaminated water. [R. Yang et al. (2018); M N Subramaniam et al.(2019)]. The overall benefit and disadvantage of these generally used methods are represented in table 2. Adsorption is the most widely used technique because of its low cost, simple obtainability of natural waste mass, simple process, recycling, use again, high heavy metal ion elimination capability all range of pH, regeneration capabilities, and removal capacity of poisonous heavy metal ions from its compound [I. Ihsanullah et al. (2016) & I. Ihsanullah et al. (2020)]. Amongst these absorbents, natural waste extract adsorbents are widely employed for transition metal ion removal because of considerably higher competence, cost effectiveness, and ecofriendly nature. The cost and sorption capability are critical characteristics in contrast the various adsorbent substance since the cost of specific adsorbents varies based on the procedure needed and the accessibility of raw adsorbent substances [M. Bilal et al., 2022].

2.2 Synthesis of Bio-adsorbent by general methods.

Several methods used for the synthesis of Bio-adsorbents from different natural bio-wastes. The preparation, characterization, and application of some adsorbents are shown in Figure 2. Bio-adsorbent synthesis comprises biomass collection, washing, drying, and size reduction, as well as pre-treatment, characterization, and any necessary adjustments. The drying process of bio-waste is conducted at different temperatures ranging from 40 to 120 ºC, it depends on the nature of the natural waste. To save electricity, bio-waste was crushed and grind manually. Bio-adsorbents cannot provide the desired efficiency when synthesized, so these adsorbents must be modified before they are applied. Bio-waste can be activated by chemical treatment, oxidation, and thermal decomposition. [MousumiBasu et al. (2017); Y. Chen et al. (2018); B.A. Ezeonuegbuet al., (2021); Y. Dan et al. (2021); A.A. Idowu et al., (2019); F. Teshale et al. (2020); M.H. Sayadi et al. (2019); D. Jiang et al. (2019); K.S. Rao et al. (2010)]. Activation of bio-wastes is accomplished by pyrolysi [J.U. Ani et al. (2020)]. The Pyrolysis of bio-waste is carried out at N2 or Ar inert atmosphere below 800 ºC, The pyrolysis of bio-waste is accomplish in inert atmosphere N_2 or Ar under 800 ◦C, and additionally, activation of the carbonized bio-waste can be carried out by chemical or heat treatment. For the synthesis of bio-adsorbents, different carbonization temperatures and activation with different contact times have been described by different studies. [M. Z. bairetsal. 2019, J.U. Ani et al. 2019 & W. Yin et al. 2019]. Similarly, chemical change may be necessary to increase the effectiveness of adsorbents in elimination of transition metals. [P. Kumar et al., 2019].

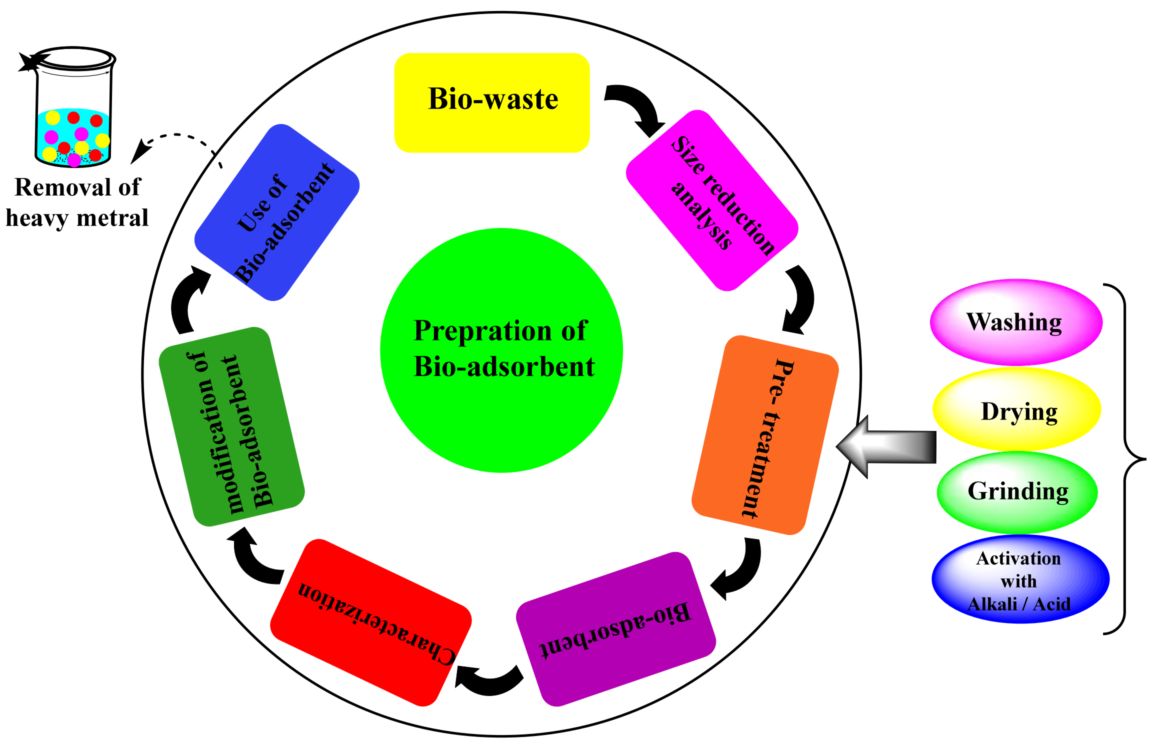


Fig 01: A common procedure for the synthesis, characterization and application of bio-adsorbents.

The waste biomass like cotton stalks, grapes, wheat husks, sun flower stalks, coconut shells, orange peel, coffee waste, groundnut, waste tea, maize corn cob, sugarcane bags, soybean hulls, wheat bran's, rice husk, water hyacinth, lemon peels, banana, sugar beet pulp, hazelnut, apple, walnut shells and Cassia fistula leaves the bark of trees and Arjun nuts can be used as adsorbents [**D. Gisi et al. 2016]**. However, in this paper, we focused on the preparation, activation of Black tea, normal tea, tamarind, soybean, rice husk, coffee and orange peel and their efficient elimination of Cr, Zn, Pb and Cu from aqueous solution. For the preparation of Bio - adsorbents the biomass was collected from the local market. In the lab these materials were washed several times to remove impurities, dried under the sun for about 48 hours followed by heating in the oven for 72 hours. These dried materials were then grounded in mechanical grinders and sieved (Table 02). For the activation of Bio - adsorbents to enhance the metal uptake efficiency, 10- 50g of untreated crude materials were treated with 1N

HCl/1N NaOH for 24 hours and placed at water bath at 70ºC for 30 minutes, followed by cooling then neutralization. The filtrates are separated and are dehydrated in the stove for 4-5 hours at 60-70ºC. (Figure 01) The prepared activated Bio - adsorbents were characterized by FTIR, SEM, AAS, BET, EDS, XRD, TGA, EDS, and XPS & Zetasizer etc.

Table 02: Details of Bio - adsorbents and their characterization

S.N.	Bio–adsorbent	Stock Solution	Chemical & Reagents	Characterization	References
1.	Tea Waste	$K_2Cr_2O_7$	HNO_3&NaCl	FTIR & AAS	U. Khalil et al. (2020)
		$Pb(NO)_2$& $Zn(NO)_2$	$NaNO_3$&NaOH	FTIR, SEM, EDS & BET	H. Çelebi et al. (2020)
	Black Tea	H_2CrO_4	HCl&NaOH	FTIR, SEM, EDS & BET	H. Çeleb et al. (2020)
		ZnSO4·7H2O	HCl&NaOH	AAS, EDXs, FTIR & FE-SEM	A. Malakahmad et al. (2016)
	Green Tea	H_2CrO_4	HCl&NaOH	FTIR, SEM, EDS & BET	H. Çeleb et al. (2020)
2	Rice husk	$K_2Cr_2O_7$	HNO_3&NaCl	FTIR & AAS	U. Khalil et al. (2020)
		Pb	HCl, NaOH& HF	SEM & XRD	Z. Babazad et al. reported 2021
		Cu^{2+} and Pb^{2+}	NaOH& H_2SO_4	AFM, FESEM, EDX, FTIR and TGA	M. Kaura, et al (2019)
3	Tamarind	$ZnSO_4$&$Pb(NO_3)_2$	NaOH&HCl.	FTIR & SEM	P. Bangaraiah et al. reported (2020)
	Tamarind wood	$(Pb(NO_3)_2)$	H_2SO_4	AAS & BET	C.K. Singh et al. (2008)
4	Soya bean	Pb^{2+}	NaOH	FTIR, SEM, Zetasizer&TGA	N. Gaur et al. (2018)
		[Pb(NO3)2]	HCl, NaOH& H_2SO_4	AAS	LI Jia et al (2011)
5	Orange peel	CuSO4·5H2O	HCl&NaOH	FTIR and SEM	Li. Sha et al. (2010)
		Zn^{2+}	NaOH, NH4OH &$Ca(OH)_2$	FT-IR	XiaominLi et al. (2008)
		Cu^{+}	NaOH, NH4OH &$Ca(OH)_2$	FT-IR	

2.3 Discussion of Bio-adsorbent:
Tea waste

The higher rate of anthropogenic activities around the world is responsible for an imbalance in the environment; especially the industrial activities are directly contaminating the water bodies by discharging their untreated effluents. This is a serious concern of researchers and scientists for the last two decades. Attempts have been made to treat wastewater to get rid of heavy pollutions and other pollutants. For this, the authors attempted to review a work done on eco-efficient adsorbents. Several studies showed waste tea as a bio- adsorbent for Cr^{4+}. According to [U. Khalil et al. (2020] biochars of waste tea and rice husk were employed for the removal of Cr^{4+} from aqueous solution with the rotating time (0.016–24 h), amount of bio-adsorbent (0.1–1.3 g L1), pH (3–10), and primary concentration of Cr^{+6} (10–250 mg L1). Under many factors the Cr(VI) sorption was undertaken, the solution pH had the main function and at pH 5.2, approximately 96.8% and 99.3% Cr^{4+} were eliminated by rice husk biochar and tea waste biochar respectively. FTIR indicated the participation of -OH, –NH2 and -COO functional groups in the sorption of Chromium on biochar. Both adsorbents efficiently eradicate Cr (VI) from wastewater. Studies of entropy, Gibbs energy, and enthalpy assessed during sorption indicated that rooibos waste tea, green waste tea, black waste tea were efficient and natural for Cr^{4+}.The highest elimination capacity for Cr (VI) was observed up to 88 %, 83 %, and 73 %. [H. Çelebi et al. 2020].The bio-sorption capacity of brew tea waste in aqueous solution having poisonous Pb^{2+}, Cd^{2+}, Ni^{2+}, and Zn^{2+} ions were reported [H. Çelebi et al 2020].The pH (2.0–6.0), contact times (1–150 minutes) and potential adsorbent dose (0.1–5.0 g) were assessed during the adsorption process. The study informed regarding removal of d-block metals has an opposite relationship with pH and a linear relationship with different factors. From brew tea waste heavy metals were eliminated at optimal pH range of 4.0 and 5.0. Studies conducted between times intervals of 2, 10, 30 and 5 min

for the sorption of Lead, Zinc, Nickel and Cadmium respectively, suggesting a bio-sorbent for the elimination of these metals from water [H. Çelebi 2020].
Similarly, Amirhossein Malakahmad suggested the same pattern for Black Waste Tea a Cost –efficient bio-sorbent for the removal of Ni and Zn of wastewater. The highest transition metal ions elimination was observed at pH 5, contact time 250min, and 20g/L of bio-sorbent. However, in binary heavy metal adsorption estimation, studies showed Ni^{2+} and Zn^{2+} adsorption tendency resembles with mono component metal adsorption [A. Malakahmad et al. 2016]. In another study, Tea Waste adsorbent was reportedly found efficient for less concentration of metal solutions. The adsorption rate was increased with an increased adsorbent dose. 96% Pb, 78% Ni and 63% Cd elimination was achieved with 0.5 gm of bio-adsorbent. The effectiveness rate further raised to 100% for Pb, 87% for Ni and 83% for Cd with1.5 gm of the adsorbent. [S.R,Singh et al. 2012] (Figure 02).

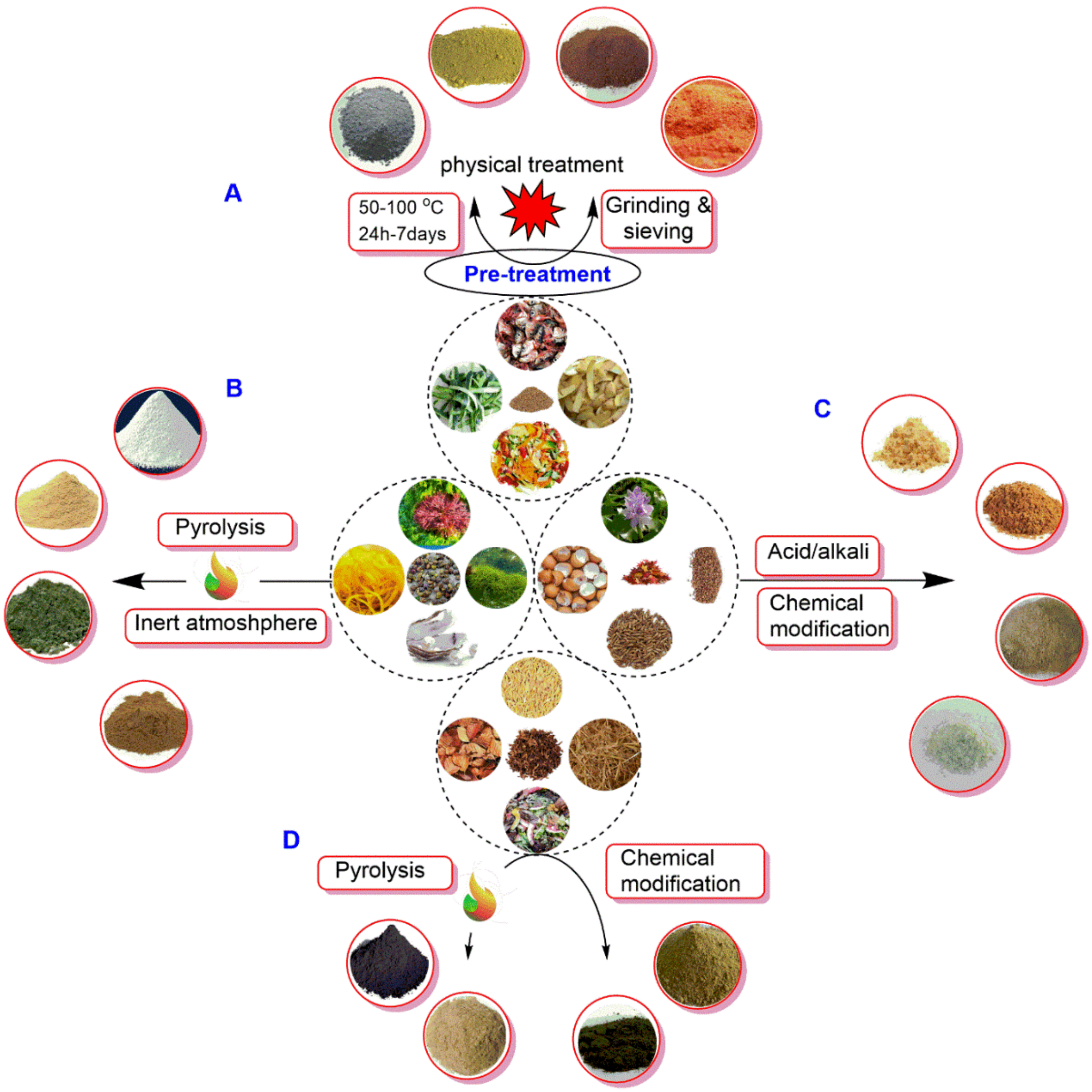


Fig 02: The most commonly used techniques of the increase of bio-adsorbents

Rafie Rushdy Mohammed et al. 2012 suggested the pH level 6 for the highest rate of adsorption for Co, Cd, and Zn. At equilibrium (qe) (12.24 mg/g) Zn, (15.39 mg/g), Co, and (13.77mg/g) Cd absorbed by 0.5 gram of waste black tea. It has been observed that the percent of elimination transition metal ions is depend on primary concentration of heavy metal ions, but related with tea waste bio-sorbent amount. The kinetics of the Co, Cd and Zn bio-sorption on the tea waste were obtained as pseudo-first-order equation. (Table: 03)

Table 03: optimum parameters are taken for adsorption on different Bio – adsorbents

S.N.	**Bio-sorbent**	**Heavy metal**	**Optimum parameters**				**% Yield**	**References**
			Primary Concentration of heavy metal ion mg L^{-1}	**pH**	**Shaking Time (min)**	**T (^0C)**		
1.	ste	Cr	120	5.2	0.016–24 h	20	99.3	U. Khalil et al. (2020)
		Cr	0.5–5.0	3.6	240min	-	97	M. Nigam et al. (2019)
		Cr	0.5–5.0	2	600min	-	90	D. Ding et al. (2017)
		Cr	0.5–5.0	2	72h	-	99.7	A.B. Albadarin et al. (2013)
		Pb	100	2	60min	25	85	S. Wan et al.(2014)
		pb	5-30	-	15-60min	-	100	S. Rani Singh et al. 2012
	lack	Zn	100	5	-	20	80	Malakahmad et al. (2016)
		Zn	100	5	10min	20	76	H. Çelebi et al. 2020
		Zn	12.24	6	180 min	25	87.1	R. Rushdy Mohammed et al. 2012
		Pb	100	4	2min	20	97.97	H. Çelebi et al. 2020
2.	Rice husk	Cr	120	5.2	0.016–24 h	20	99.3%	U. Khalil et al. (2020)
		Cr	0.5–5.0	7	120min	-	86	A. Sarkar et al. (2019)
		Pb	1.95	5.5	15-120min	-	96.41 %	R. Amen et al. 2020
3.	Tamarind	Cr	0.25 – 1	3 - 5	1h	-	56.8	V. H. Apsara et al. al.(2020)
		Pb	46.49 mg/l	7.64	47.65 min,	60	83.52	P. Bangaraiah et al. (2020)
		Zn	20.87	6.98	22.84 min	60	63.7%	P. Bangaraiah et al. (2020
	Tamarind wood	Pb	40	6.5	40min	25	97.95	C.K. Singha et al. (2008)
4.	Soya bean	Pb	400	7	8h	25	80	LI Jia et al (2011)
		Zn	20-100	2.0 - 9.0	10 – 140min	50	99	J.S.Yadav et al.(2017)
5.	Pomegranate Peel	Cu	30	5-6	1h	25	80	M. K. Rashed et al. (2020)
		Zn	30	5-6	1h	25	32.5	
6.	Orange peel	Cr	0.5–5.0	2	300min		97	E. Ben Khalifa et al. (2019)
		Cu	5	5.3	1.5h	25	95	L. Sha et al. (2010)
		Zn	0.1	6	60 min	25	60	XiaominLi et al.(2008)
7.	Coffee grounds	Cr	0.5–5.0	3	140min		96	A.E. Obaya Valdivia et al. (2020)
		Cu	0.5 – 4.5	6	10min	25	98.8	L. O. E. Agwaramgbo et al. (2016)
		Zn	0.5 – 4.5	6	10min	25	98	

Tamarind

Using Tamarind indica, Pb and Zn were efficient eliminated from the aqueous solution, for which various parameters were taken. The pH (6.98 to 7.64), shaking time (22.84 to 47.65), initial heavy metal ions concentration (20.87 to 46.49 mg/l) and weight of bio-adsorbent (0.78-1.23g). A minimum of 63.7% Zn (II) and 83.52% Pb (II) can be removed by tamarind, according to these parameters. [P. Bangaraiah1 et al. (2020], According to a study, tamarind wood was activated with H2SO4 to create inexpensive carbon used to eliminate Pb2+ from contaminated water. The chemical properties, pH, contact time, weight of adsorbent, and main concentration parameters of the biosorbent were investigated. Similarly, tamarind wood shows a higher efficiency for removal of Pb (II) approximately 97.95% [C.K. Singh et al. reported 2008].

Soybean

Soybean was used as a bio-sorbent to elimination lead and arsenic from wastewater. The bio-sorption of lead and arsenic was observed at 37 °C with adsorbent dose (1- 4 g/100 ml), adsorbed amount (3 g/100 ml), pH (2-4) and shaking time (1hrs).This work indicated the elimination of transition metals have a relationship with different parameters. Soybean adsorbent was found to be endothermic to the adsorption of lead and Arsenic [N. Gaur et al. 2018]. The soybean hull has an able bio-sorption capability for Pb (II), up to 20% of the weight of dehydrated bio-sorbent. It is found that the adsorption rate is conscious of determining the pH and The pH solution had the main function and maximum 80% lead was removed by soybean adsorbent at pH 7[LI Jia et al. 2011] in this study sodium hadroxide and citric acid was used for activation of soybean hulls. Soybean Hulls were working for the elimination of Zn from water samples with optimized parameters such as amount of bio-sorbent, primary concentration, shaking time, and pH value.99% removal of Zn (II) was achieved with different parameters [J.S.Yadav[1] et al. 2017].

Pomegranate

It is found by this study that cadmium, zinc, and copper were eliminated from wastewater by Pomegranate peel. Artificial water was used in this process and the pomegranate peel was dried and, dried its particle size was reduced to less than about 1mm. This experiment was done at 25 ºc room temperature and 5 - 6 pH value. The impact of shaking time and primary concentration of transition metal ion on sorption was observed in this experiment. From which it was found that approximately (80%) Cu^{2+}, (50.5%) Cd^{2+} , and (32.5%) Zn^{2+} ions can be easily removed from pomegranate peel [M. K. Rashed et al. 2020]. (Table: 04)

Table 04:Percentage of adsorption of heavy metals on Bio – adsorbents

S. No.	Bio-adsorbent Name	Removal of Metals	%of Adsorption	References
1.	Tea waste	Cr	90 - 99.3	U. Khalil et al. (2020),M. Nigam et al. (2019), D. Ding et al. (2017), A.B. Albadarin et al. (2013)
		Pb	85 - 100	S. Wan et al.(2014), S. R. Singh et al. 2012
	waste rooibos tea	Cr	73	H. Çelebi et al. (2020)
	waste green tea	Cr	83	
	waste black tea	Zn	76 – 87.1	Malakahmad et al. (2016), R. R. Mohammed et al. (2012), H. Çelebi et al. (2020)
		Cr	88	H. Çelebi et al. (2020)
		Pb	97.97	
2.	Tamarind Fruit Shell	Cr	76 - 98	M. Shahmoradi et al. (2014)
		Zn	63.7	P. Bangaraiah et al. (2020)
		Pb	83.52	
3.	Soybean	Zn	99	J.S.Yadav et al.(2017)
		Pb	80	LI Jia et al. (2011)
4.	Pomegranate Peel	Cu	80	M. K. Rashed et al. (2020)
		Zn	32.5	
5.	Rice husk	Cr	86 – 96.8	A. Sarkar et al. (2019), U. Khalil et al. (2020)
		Pb	76 - 97	M. Kaura, et al 2019, R. Amen et al. 2020, Z. Babazad et al. 2021
		Cu	82	M. Kaura, et al 2019
6.	Orange peel	Cr	97	E. B. Khalifa et al. (2019)
		Zn	78	XiaominLi et al.(2008)
		Cu	95	L. Sha et al. (2010)
7.	Coffee Waste	Cr	96	W. Cherdchoo et al. (2019)
		Zn	74	L. O. E. Agwaramgbo et al. (2016)
		Cu	92	

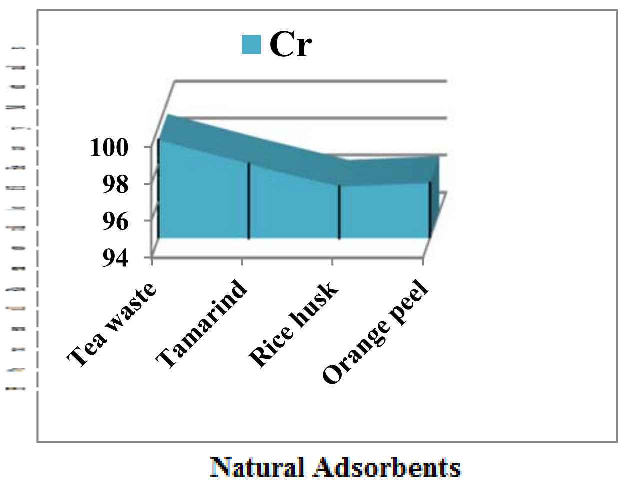
Table 05: adsorption isotherms of heavy metals on various Bio-adsorbents

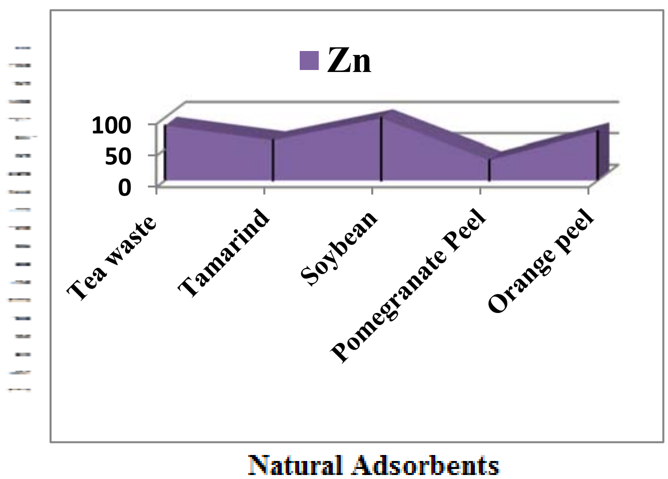
S. No.	Adsorbent	Heavy Metal	Freundlich isotherm			Langmuir isotherm				Reference
			n	K_f(mg g^{-1})	R^2	q_m(mg g^{-1})	K_L (L mg^{-1})	R_L	R^2	
1.	Tea waste	Pb	2.734	5.189	0.961	1.197	0.405	0.03	0.997	H. Çelebi et al. (2020)
		Zn	4.782	6.175	0.577	2.468	0.218	0.05	0.997	
		Cr	0.27	104.22	0.84	38.62	0.06	-	0.96	U. Khalil et al. (2020)
	waste black tea	Cr	2.08	36.29	0.94	9.14	0.07	0.129	0.96	H. Çelebi et al. (2020)
	waste green tea	Cr	2.94	124.28	0.93	8.56	2.61	0.004	0.96	
	waste rooibos tea	Cr	2.31	28.14	0.89	5.12	3.27	0.003	0.94	
2.	Tamarind	Pb	0.580	0.382	0.993	1.86	-	-	0.974	P. Bangaraiah et al. (2020)
		Zn	0.421	0.588	0.977	1.62	-	-	0.982	
		Cr	0.405	2.449	0.983	14.29	0.14	-	0.974	M. Shahmoradi et al. (2014)
3.	Soybean	Pb	0.161	15.1	0.993	40.8	4.66	-	0.999	F. Zhang et al. (2021)
		Pb	0.256	0.176	0.94	0.72	0.018	-	0.96	N. Gaur et al. (2018)
4.	Pomegranate Peel	Cr	0.764	1.900	0.997	0.4066	0.069	0.224	0.907	R.A.K. Rao et al., 2010
		Pb	4.198	72.85	0.954	166.63	0.347	0.00071	0.997	C¸ i˘gdem Ömero˘gluAya et al., 2012
		Pb	0.503	6.01	0.691	113.25	0.023	-	0.974	M. Alam et al., 2012
5.	Rice Husk	Cr	0.26	99.13	0.77	30.05	0.09	-	0.93	U. Khalil et al. (2020)
		Cu	0.7159	0.495	0.993	13.003	0.025	-	0.9686	M. Kaura et al. (2019)

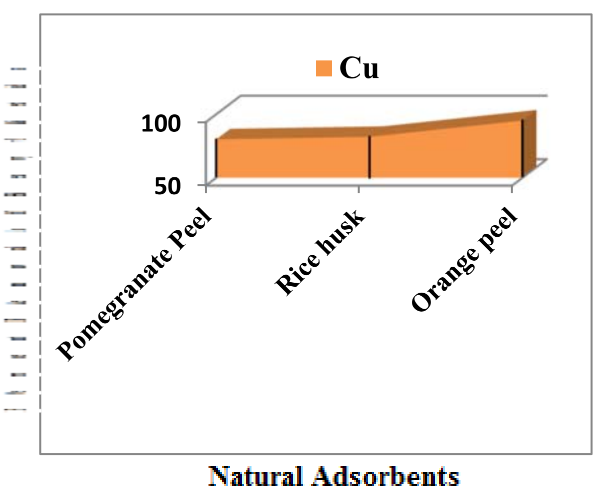
		Pb	0.5772	0.876	0.999	6.101	0.132	-	0.9576	
6.	Orange peel	Cu	2.589	6.296	0.925	40.37	0.095	-	0.996	L. (2010)
		Zn	0.37	4.21	0.95	0.76	0.72	-	0.98	XiaominLi et al.(2008)
7.	Coffee Waste	Cr	3.65	2.353	0.9810	6.961	0.1805	0.44	0.9821	W.E. Oliveira et al., 2008
		Cu	5.01	3.702	0.9025	7.496	0.4232	0.24	0.9783	
		Zn	6.07	2.721	0.8421	5.565	0.2238	0.45	0.9524	

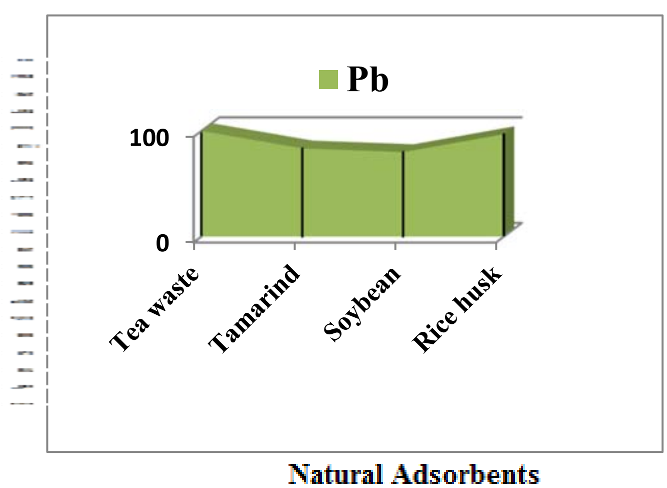
Coffee waste

Coffee waste was taken as a Bio - adsorbent for the elimination of Cu and Zn from wastewater. Various effect of amount of bio-sorbent, type of heavy metal, and the occurrence of a different heavy metal on adsorption was observed in this experiment. In this study, the result is found that increasing the amount of bio-adsorbent increases the removal of serious heavy metals from the contaminated water. From which it found that 73-92% copper and 50-74% zinc can be easily removed from Coffee waste [L. O. E. Agwaramgbo et al. 2016]. (Figure 03)









Rice husk

Different adsorbents are used to elimination transition metals from wastewater, of which rice bran has also proved to be a good adsorbent. Rice husk used as a potential adsorbent. By this process Pb and As are easily removed from water by using bio-adsorbent got from rice husk. The highest metal ions elimination was observed at pH (3–9) pH, (3–90min) shaking time, (0.5–6 g/l) bio-sorbent dose and primary bio-adsorbed concentration (10–100 μg/l) primary metal ion concentration. According to this study 97% Lead and 85% Arsenic elimination was achieved [Z. Babazad et al. 2021]. Rice husk was employed for the elimination of Cu^{2+} and Pb^{2+} from contaminated water with the shaking time, bio-adsorbent amount, pH, and primary concentration of heavy metal ions. Under many factors the Cu^{2+} and Pb^{2+} adsorption was undertaken, the solution pH had the main function and at pH (4-6.7), approximately 82% Cu and Pb 76% respectively were eliminated by rice husk biochar [M. Kaura, et al reported 2019].

Orange peel

Mg^{2+}& K^{+} type two novel adsorbents were made by raw Orange peel. These two adsorbents are used to the removal of Cu^{2+}. The adsorption rate was increased with increased contact time [Sha L et al. 2010]. Co^{2+}, Ni^{2+}, Zn^{2+} and Cd^{2+} are easily removed from chemically synthesized orange peel. Orange peel is synthesized by different alkali and different acids. The impact of pH, shaking time, shaking speed and primary concentration of transition metal ion on sorption was observed in this experiment. 95% Ni, 78% Co and 60% Zn and 30% Cd elimination was achieved with these parameters. Characterization of adsorbents was performed using various instrumental techniques likes FTIR and SEM [Xiaomin et al. 2008].The sorption isotherms of Pb, Cu, Zn and Cr heavy metal values on waste tea, black waste tea, green tea, waste rooibos tea, tamarind, Soya bean and rice husk have been mentioned in table 05.

3 Conclusions

The developments in applications of bio-adsorbents for the elimination of various toxic transition metals from wastewater are reviewed. The outcome of the present review reveals that various bio wastes and adsorbents derived from them can exhibiter mark able effectiveness in elimination of transition metals from the contaminated water. This article will provide understanding on the sustainable exploitation of bio contaminants as potential sorbent equipment and will support them to investigate this readily available waste biomass for remediation of waste water. Huge quantity of bio contaminants for the development of effective bio-adsorbents to reduce the cost of contaminated water treatment can be an eco-friendly and cost effective approach of management of these wastes and decontamination of water. This review endeavors to assess the potentiality bio-adsorbents derived from bio wastes such as coffee, rice husk, orange peel, tea, soya been, pomegranate peel, tamarind, towards the adsorption of pollutants from wastewater. It has been found that reducing water contamination of transition metals by adsorption is quite significant, cost-effective, and more beneficial than other methods.

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