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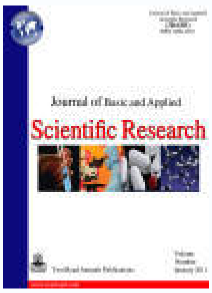

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Effectiveness of Algae on Growth of Parsley (*Petroselinum crispum)* and Spinach *(Spinacia oleracea)* Plants under the Stress of some Heavy Metals

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ABSTRACT

Soil contamination with heavy metals has become an environmental crisis due to their long-term stability and adverse biological effects. Therefore, bioremediation is an eco-friendly technology to remediate contaminated soil. This study was conducted in two pot experiments at the greenhouse of the National Research Center. Experiments were carried out to study the influence of algal extract on growth of spinach and parsley plants under different levels of polluted soil. The algal species used in this study were *Chlorella vulgaris* and *Anabaena sphaerica* which used in a mixture with concentration (2%). Increasing the level of pollution decreased growth of spinach and parsley plants in presence of lead or cadmium. Adding the mixed algal extract reduces the impact of pollution on the growth. In general addition of heavy metal decreased all macronutrients (N, P and K) compared with control treatment either in presence of algae or not. The uptake of nitrogen, phosphorous and potassium by spinach and parsley plants increases when treated with algae. Application of algae reduced the concentration of Pb or Cd at the same treatments for spinach and parsley plants. Data also, show a great variation in value of Cu content in spinach or parsley as it increases with increasing levels of soil pollution under all treatments.
KEY WORDS: heavy metal, microorganisms, bioremediation, algae,polluted soil, parsley, spinach.

INTRODUCTION

Environmental pollution with heavy metals is a dangerous crisis, and the different uses of these elements have enhanced in the world due to industrial progress **(Dhal et al., 2013).** These pollutants are toxic and pose a severe threat to human and environmental health due to their accumulation in the food chain **(Song et al., 2017, Tao et al., 2017).**

Heavy metal toxicity to various environmental niches is a great concern for environmentalists. Because these metals are difficult to be eliminated from the environment and, unlike many other pollutants, cannot be degraded chemically or biologically and are eventually indestructible. Hence, their toxic effects last longer **(Ahemad, 2012).**

Increasing the use of chemical fertilizer led to high costs in vegetable production. It affected soil fertility and a series of negative environmental consequences **(Tilman et al., 2001)** because some fertilizers contain heavy metals (e.g. cadmium, and chromium) and high concentrations of radionuclides. As the global food demand is expected to double by 2050 **(Singh, 2016),** it has become essential to find alternative untraditional methods to increase crop production. Several methods have been utilized for remediation of metal contaminated soils **(Liu et al. 2018).** The remediation of metal-contaminated soils consequently becomes imperative because such soils generally cover large areas that are rendered inappropriate for sustainable agriculture. One of them is the bioremediation method. The bioremediation methods are gaining increasing prominence because their cost-effective**,** environment friendly **(Shah &Daverey 2020),** simple to implement **(Liu et al. 2018),** without disturbing the soil fertility and biodiversity **(Ahmad et al. 2016, Xiao et al. 2019).**

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Phytoremediation has emerged as the most desirable technology which uses plants for removal of environmental pollutants or detoxification to make them harmless **(Cunningham and Berti, 1993).** Many living organisms can accumulate certain toxicants to body concentrations much higher than present in their environments **(Nyangababo et al, 2005; Igwe et al, 2008 and Kord et al, 2010).** Thus, the use of plants for the decontamination of heavy metals has attracted growing attention because of several problems associated with pollutant removal using conventional methods.

Recently, the strong interest in crop production has been focused on using microorganisms, including cyanobacteria and green algae, as eco-friendly biofertilizers, which can be an alternative to chemical fertilization and offer economic and ecological benefits to farmers. Microalgae only need sunlight, simple nutrients, including nitrogen, sulfur, phosphorous, and carbon dioxide (Pignolet et al., 2013), and complete an entire growth cycle within hours. Their inexpensive growth requirements as well as their advantage of being utilized simultaneously for multiple technologies (e.g., biofuel production, antimicrobial compounds **(Abd El-Aty et al., 2014)** and bioremediation of heavy metals **(Abd El-Aty et al., 2013**) and organic contaminants **(Abd El-Aty et al, 2015)** have made microalgae more popular for various biotechnological applications **(Suresh Kumar et al., 2015).**

Previous studies proved that cyanobacteria could be developed as a bioremediating agent for plant growth promotion and salt-affected soil remediation through the most effective mechanisms, such as nitrogen fixation, production of extracellular polysaccharides, and growing the organic carbon contents **(Li et al., 2019).** Therefore, cyanobacteria inoculation can be considered a novel technique for remediation of contaminated soil **(Biglari Quchan Atigh et al., 2020).**

The genus *Chlorella* includes single-celled, spherical green microalgae of about 2–10 μm in diameter. *Chlorella* is currently the most cultivated microalga worldwide, mainly due to its rapid growth rate, high photosynthetic efficiency and high nutritional value **(Masojídek and Torzillo, 2008).** *Chlorella* cells can contain up to 70% of protein (in dry weight), making the biomass valuable to the food industry **(Liu & Hu, 2013).** *Chlorella vulgaris* is one of the most commonly reported Chlorella species for heavy metal removal. Algal extract foliar application was recommended for increasing the growth parameters of tomato **(Nour et al., 2010),** green gram **(Pramanick et al., 2013),** garlic plants **(Shalaby and El-Ramady, 2014),** Parsely **(Kandil et al., 2020)** and Spinach **(Mahmood et al., 2019).**

Petroselinum crispum (Mill), popularly known as parsley, belongs to the family Apiaceae **(Borges *et al.,* 2016).** It is native to Europe and the Mediterranean region **(Sayilikan *et al.,* 2011).** Parsely is an evergreen biennial or shortlived perennial herb **(Midrad, 2011).** It has strong aromatic compound leaves inflorescences in the shape of terminal umbels over the leaves, with small yellow-greenish flowers **(Borges et al., 2016).** Parsley is widely cultivated commercially for its strong aromatic edible leaves, fleshy roots **(Kmiecik and Lisiewska, 1999)** and essential oils **(Mylavarapu and Zinati, 2009).** The vitamin C rich leaves are used fresh, dried or frozen as a garnish or spice to add flavour to food **(Mirdad, 2011).**

Parsley is a good source of carotene (pro-vitamin A), vitamins B1, B2 and C, and iron and other minerals **(Osman and Abd El-Wahab, 2009).** The plant has many medicinal uses that include antispasmodic carminative, diuretic; since it contains essential oil of 0.3% in leaf and 2-7% in the fruit **(Midrad, 2011).** The oil contains pinene, myrcene, phellandrene, cymene, methatriene, elemene, myristicin and apiole **(Petropoulos et al., 2008).** It is used in the food industry or as a fragrance in manufacturing perfumes **(Diaz-Maroto et al., 2002).**

Spinach *(Spinacia oleracea* L.*)* is one of the most important and commonly consumed leafy vegetables. It is commercially known as spinach, which possesses therapeutic properties and is a rich source of flavonoids and phenolic compounds besides its economical and ease of availability **(Metha and Belemkar, 2014).** Spinach has low calorific value with an ample supply of vitamins, micro-and macronutrients, and other phytochemicals, including polyphenols and fibre **(Llorach et al., 2008).**

This study was conducted to assess the ability of of mixed extract of two different algal speceies namely *Anabaena sphaerica* and *Chlorella vulgaris* as biofertilizers to improve the growth and chemical composition of parsely and spinach cultivated in contaminated soil with some heavy metals.

MATERIALS AND METHODS

Soil description and characterization

The soil was collected from the Agricultural Experimental Station of National Research Centre, Nobaria sector, Behara governorate, Egypt. This soil was sandy in texture and represented the deserted light-textured soils of Egypt. The sample was gathered from 0 to 30 cm of soil depth, air-dried at room temperature, ground, sieved (2 mm mesh). The physic-chemical characteristics of the studied soil were determined according to **Klute, (1986),** contents of organic matter and $CaCO_3$ as well as EC and pH were evaluated according to **Black *et al.,* (1982).** Total N and available P, K, total Cu, Pb, Cd and available Cu, Pb and Cd were also determined according to **Jackson (1973)** and summarized in Table (1).

Table (1): Some physical and chemical properties of El-Nobaria soils.

% Sand	% Silt	% Clay	Soil texture	pH 1:2.5	E.C dS/m	% $CaCO_3$	% O.M	%			Available heavy metals (ppm)		
								N	P	K	Pb	Cd	Cu
93.47	5.5	1.03	Sand	7.68	0.62	0.7	0.3	0.016	0.013	0.011	0.44	0.009	0.32

Soil pre-treatment

The sampled soils were subdivided, each soil sample weighed 5kg was put into a plastic pots. A Lead (Pb) and cadmium (Cd) solution was added separately into the plastic pots to simulate soil contamination. The concentration of Pb and Cd in soil was (0, 200 and 300 ppm).

Algal strains and growth condition

The two microalgal species used in this study were *Anabaena sphaerica*, N_2-fixing *Cyanobacterial* species and *Chlorella vulgaris*, green alga isolated from the phytoplankton community of the River Nile, purified and recultivated in a fresh algal nutrient medium BG11 **(Carmichael, 1986).** *Chlorella vulgaris* isolated in 100 % $NaNO_3$ (1.5 g/l), where $NaNO_3$ was entirely excluded from *Anabaena sphaerica* media **(Abd El- Aty, et al., 2015).** The cultures were incubated under continuous white fluorescent illumination (33.3 E/m2/s) and temperature of 24 ± 2°C for *Chlorella vulgaris* and 30 ± 2°C for *Anabaena sphaerica* growth. Cultures were shaken once daily to prevent clumping of algal cells. Cultivation was carried out in sterilized conical flasks. The cultivation time differed from one strain to another depending on the optimum growth rate till reaching the stationary phase, which always ranged between (10-15) days.

Preparation of algal biomass and extract

At maximum growth of each species, the algal species were harvested by centrifugation at 3000 rpm for 15 min. Then, after removing clear liquid, the algae pellet was washed several times by distilled water till the effluents became almost transparent. The washed biomass was then dried in an oven at 40°C until a constant weight was reached. The dried biomass was then ground into fractions. The algae were stored in an airtight container in a dry place. The preparation of algal extracts and the chemical composition of algal strain were previously described by Mahmoud et al., 2019.

Seedling experiments

Pots experiment were carried out in the National Research Centre (NRC) greenhouse, Dokki, Giza, Egypt. Mixed algal extract concentration (2%) was used. Ten seeds of the two studied plants, namely parsley *(Petroselinum crispum)* and spinach (*Spinacia oleracea*), were planted in 5kg capacity of air-dried soil plastic pots by pressing them into contaminated soil to a depth of 0.5 cm and the following treatments were applied: 1- Control, 2- 200 ppm Cd, 3- 300 ppm Cd, 4- 200 ppm Pb, 5- 300 ppm Pb, 6- Control with algae, 7- 200 ppm Cd with algae, 8- 300 ppm Cd with algae, 9- 200 ppm Pb with algae and 10- 300 ppm Pb with algae. The pots were watered daily to 70% of the water holding capacity, thinned out to 5 seedlings per pot after 10 days, and then treated with algae and allowed to grow for 75 days. The necessary mineral fertilizers were applied (20 kg fed^{-1} ammonium sulphate, 100 kg fed^{-1} superphosphate and 50 kg fed^{-1} potassium sulphate) to each pot. At harvesting, plants were carefully removed, washed with tap water (to remove any attached particles), rinsed twice with distilled water. Fresh and dry weights were recorded. Nitrogen, phosphorus, potassium and trace elements (Cd ,Pband Cu) in the plant were analyzed. All the analyses were determined using the standard methods of **Jackson (1973), Lindsay and Norvell (1978).**

Statistical analysis of data
All the analytic determinations were carried out in triplicates. Statistical analyses were performed as described by **Sendecor and Cochran (1982)** and the treatments were compared by using the L.S.D. test at 0.05 level of probability.

RESULTS AND DISCUSSIONS

algae play an important role in improving growth of many plants when applied as biofertilizers. This evidence was clearly appeared in growth criteria of spinach plant which grown in soil polluted by Pb and Cd in presence or absence of algal addation are presented in Table (2) and Fig (1).

The growth of spinach plants which grown in polluted soil in terms of fresh (FW) and dry weight (DW) was increased by algal application when compared with the same treatments in absence of algal addition. Exposing of spinach plants to various concentrations of lead or cadmium resulted in a significant reduction of fresh and dry biomass. In general, increasing the level of pollution with lead or cadmium led to decreases in growth while adding mixed algal extract reduce the impact of this pollution on the growth of spinach. This results was confirmed by **Mahmoud et al.(2019)**.

Table (2): Growth criteria of spinach plants cultivated in soil polluted with cadmium and lead in absence and presence of algae

Treatments	rate	FW (g)	DW (g)	N (%)	P (%)	K (%)
Without Algae						
Control	0	52.7	12.8	2.04	0.10	2.1
Cd	200	72.5	16.6	2.41	0.14	2.5
	300	45.4	13.1	2.56	0.12	3.0
Pb	200	81.6	18.5	3.55	0.16	3.2
	300	47.8	13.7	1.44	0.11	3.0
With Algae						
Control	0	60.7	14.0	1.70	0.05	2.5
Cd	200	116.2	18.7	2.18	0.17	3.4
	300	99.0	17.7	2.80	0.16	4.5
Pb	200	70.5	16.9	2.80	0.18	2.8
	300	64.0	16.2	1.86	0.15	3.7
LSD at 0.05%		1.11	0.24	0.06	0.005	0.02

The obvious impact of alga concentrate might be credited with its impact in expanding cell layer penetrability and advancing plant productivity in the retention of supplements . In addition, green growth concentrate may assume a part through its substance of cytokinins in postponing the maturing of leaves by decreasing the debasement of chlorophyll, (Enan et.al 2016) .The highest fresh and dry weight of spinach plant was recorded at 200 ppm Cd after adding the of mixter algae (116.2, 18.7) for fresh and dry weight respectively. Treatment with mixed algal extract led to an increase in spinach growth by (60.28%, 25.5%) for fresh and dry weight compared with control, respectively, when treated with 200 ppm cadmium. Blue green algal extract excretes a great number of substances that influence plant growth and development **(Ordog, 2004).** may be due to algae extract contains cytokines which induce the physiological activities and increase total chlorophyll in plants which, reflects on the activity of photosynthesis and the synthesized materials which will positively reflects on the growth characteristics (Ghalab and Salem, 2001) and (Enan et al.,2016).

These results are in line with **(Chekroun and Baghour, 2013)** who found that the accumulation of heavy metals by micro and macroalgae provides an advantage for phytoremediation over other methods which are more costly and not eco-friendly.

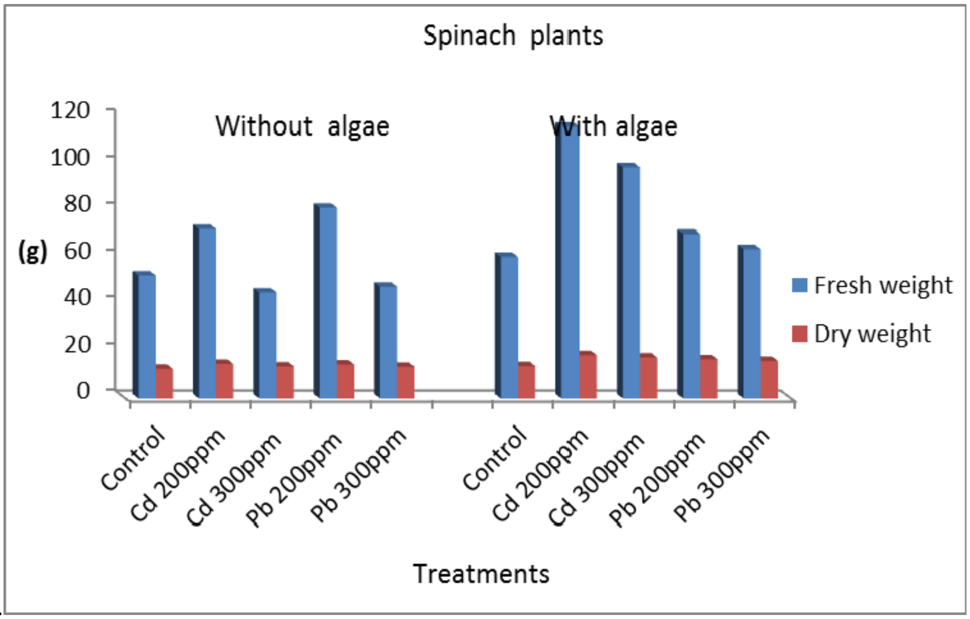

Fig. (1): Effect of Cadmium and lead in absence and presence of algae on fresh (FW) and dry weight (DW) of spinach plants.

The concentration of N and K in spinach plants significantly increased in presence of different concentrations of heavy metals either cadmium or lead when compared with control except at the concentration of 300 ppm Pb. Also, the phosphorous was increased when the concentration of 200 ppm of Cd or Pb was added ,however as the concentration of heavy metal was increase to 300ppm, the phosphorous content of the spinach plant was decreased. This results have the same trend in absence and presence of algae (Table 2 and Fig 2).

These results were in accourdance with those obtained by **Ordog (2004)** who documented that the suspension of cyanobacterial and microalgal extract contains a special set of biologically active compounds including plant growth regulators, which can be used for treatment to decrease senescence, transpiration as well as to increase leaf, chlorophyll, protein content and root development, also**, Ghallab and Salem (2001)** found that the two biofertilizers increased nutrients content in wheat plant. A Similar trend was observed by **Adam (1999)** who showed an improvement in the nitrogen contents of the seed and related processes of wheat, sorghum, maize and lentil under application of cyanobacteria as biofertilizers.

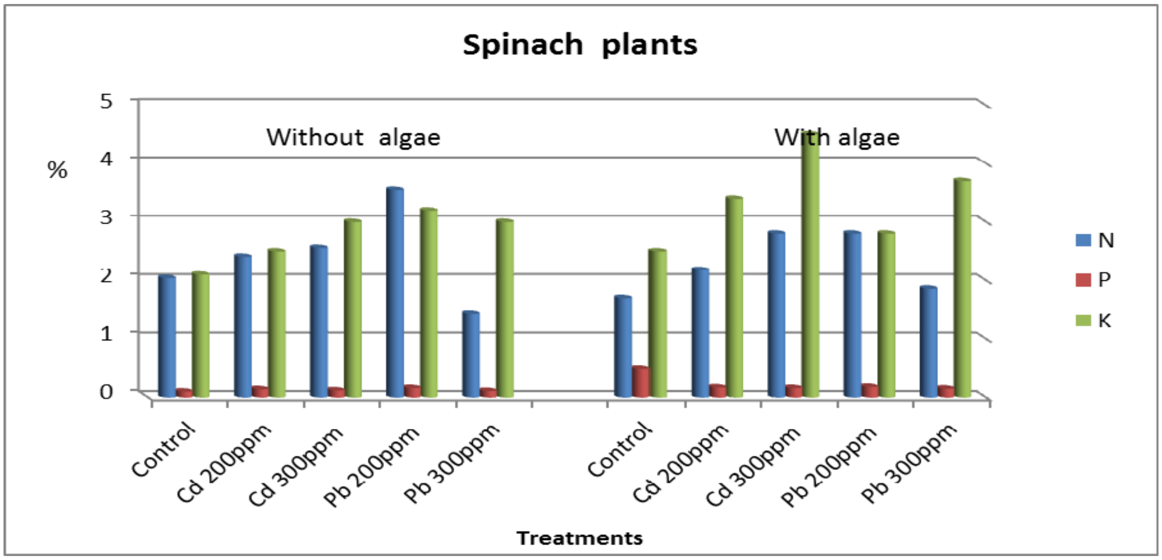

Fig. (2): Effect of Cadmium and lead in absence and presence of algae on nitrogen (N), phosphrous (P) and potassium (K) contentes of spinach plants.

Data recorded in Table (3) and Fig (3) show the effect of different levels of heavy metals namely Cd and Pb in absence and presense of algae on the growth criteria of parsley plants which represented by fresh weigt,dry weight ,N, P and K . It is noticed a significant decrease in the fresh and dry weight with an increase in the concentration levels of heavy metals in absence of algae. Meanwile there is an increase in fresh and dry weight after treatments with algal extract under all levels of heavy metals treatments. These results in harmony with those obtained by **Kandil et al., (2020)** who reported that the application of algae caused positive effect on parsley fresh and dry weight.

Table (3): Growth criteria of parsley plants cultivated in soil polluted with cadmium and lead in absence and presence of algae

Treatments	rate	FW (g)	DW (g)	N (%)	P (%)	K (%)
Without Algae						
Control	0	26.0	14.8	0.70	0.19	1.65
Cd	200	23.2	12.3	0.68	0.32	1.58
	300	24.7	12.4	0.44	0.25	1.48
Pb	200	22.0	12.2	0.52	0.28	1.64
	300	18.0	14.5	0.45	0.22	1.10
With Algae						
Control	0	30.5	15.5	0.70	0.30	1.50
Cd	200	42.2	23.1	0.69	0.40	1.11
	300	30.8	17.5	0.48	0.34	1.60
Pb	200	37.6	21.0	0.66	0.42	1.42
	300	35.9	17.5	0.46	0.38	1.60
LSD at 0.05%		0.96	0.31	0.004	0.002	0.05

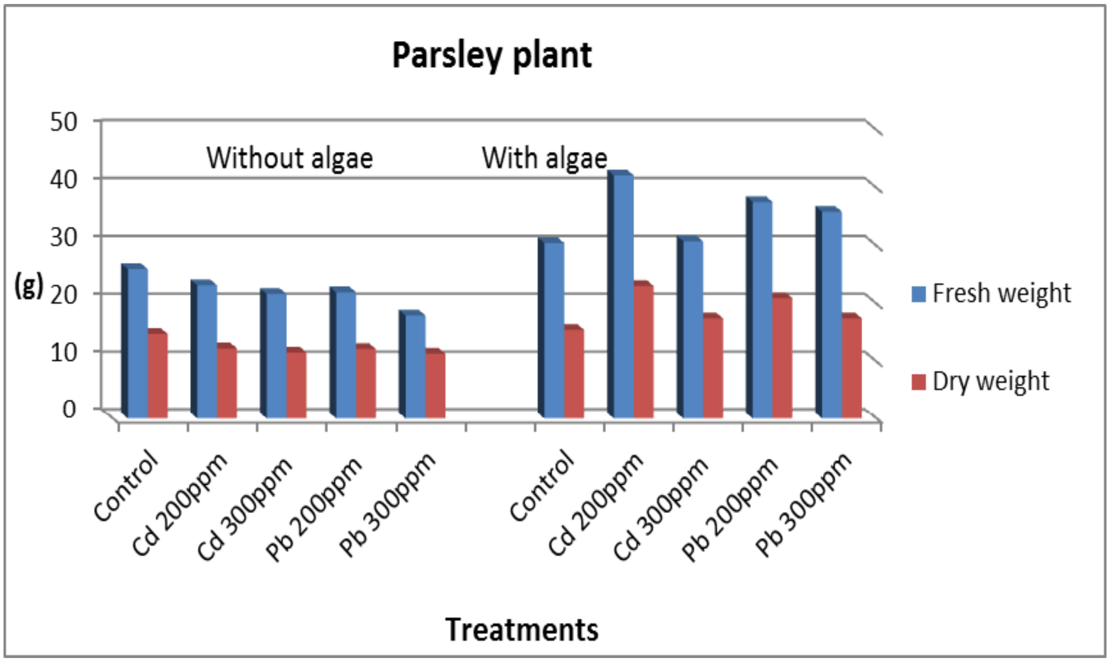

Fig.(3): Effect of Cadmium and lead in absence and presence of algae on fresh (FW) and dry weight (DW) of parsley plants.

The highest fresh and dry weight was obtained at 200 ppm Cd in presence of algae (42.2, 23.1 g) for fresh and dry weight of parsley respectively. This result is comfied with **Kublnovskaya et al., (2019),** who stated that using *Anabaena sphaerica* as the foliar application biofertilizer gave highest fresh and dry weight.

Data presented in Table (3) and Fig (3) cleary show that the application of different concentrations of heavy metal decreased all macronutrients (N, P and K) as compared with control either in presense or absence of algal application. Despite that, the macronutrient uptake by plants increase as a result of the increase in the dry weight of parsley plants.

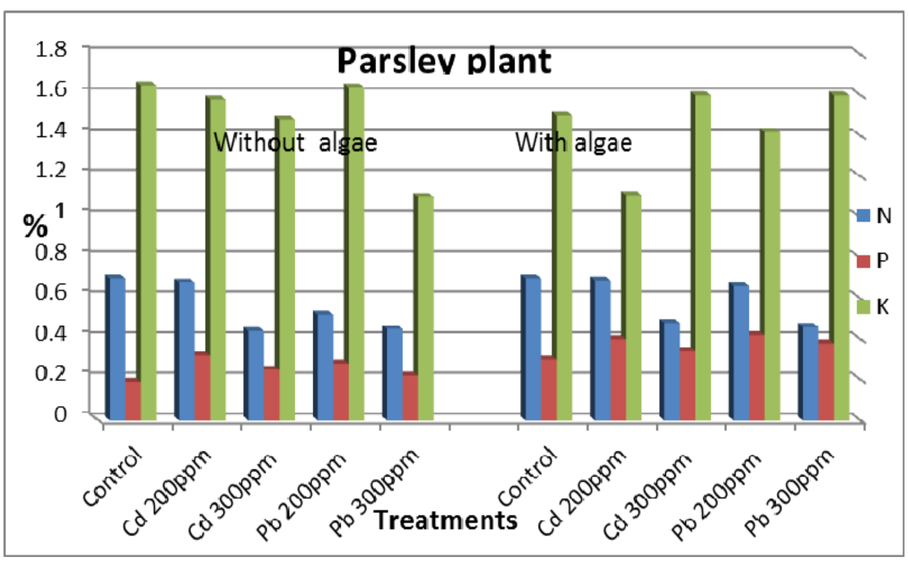

Fig.(4): Effect of Cadmium and lead in absence and presence of algae on nitrogen (N), phosphrous (P) and potassium (K) contentes of parsley plants

These results are in harmony with those obtained by **Brahmbhatt and Kalasariya (2015)** who reported that addition of algal extracts can enhance plant growth of radical. **Ghallab and Salem (2011)** found that the two biofertilizers increased nutrients content in wheat plants. Also, **Mahmoud et al. (2019**) reported that *Anabaena sphaerica* strain gave better results for spinach growth and macronutrients.

Data presented in Table (4) and Figs (5 and 6) showed that the effect of bioremediation with algae on spinach and parsley plants grown in soil polluted with different levels of heavy metals (Cd and Pb). The concentration of Cd in spinach and parsley plants which grown in diferent levels (Cd and Pb) significantly increased by Cd addition either in presence or absence of algae . The highest values of Cd concentrations in spinach and parsley plants were recorded (6.8 and 21.5 ppm) at 300 ppm Cd in absence of algal treatments for spinach and parsley respectively. However, the application of mixed algal extract reduced polluted Cd to (5.3 and 13.4 ppm) at the same treatments for spinach and parsley plants recorded.

Table (4): Effect of Cadmium and lead in absence and presence of algae on on heavy metals contentes (Cd, Pb and Cu) of spinach and parsley plants

Treatments	rate	spinach plants			parsley plants		
		Cd (ppm)	Pb (ppm)	Cu (ppm)	Cd (ppm)	Pb (ppm)	Cu (ppm)
Without Algae							
Control	0	3.0	5.50	8.9	3.5	5.6	14.4
Cd	200	5.5	5.20	8.4	15.5	5.8	15.1
	300	6.8	5.20	9.0	21.5	6.1	21.5
pb	200	3.3	15.90	10.9	3.6	15.0	15.4
	300	3.5	19.00	11.7	3.7	17.0	15.9
With Algae							
Control	0	2.5	4.50	9.5	2.5	4.5	15.5
Cd	200	4.4	5.50	8.8	9.0	3.0	13.8
	300	5.3	6.50	9.7	13.4	5.5	17.2
pb	200	1.4	11.30	9.5	1.0	12.0	12.5
	300	1.8	15.50	10.0	1.4	15.4	13.0
LSD at 0.05%		0.03	0.25	0.04	0.04	0.23	0.05

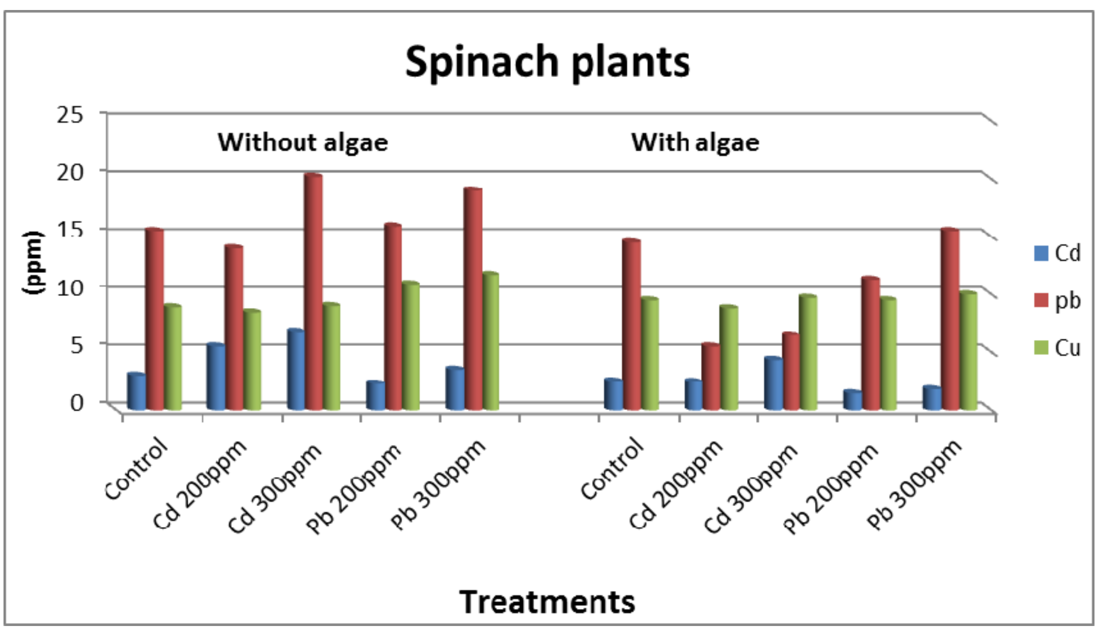

Fig.(5): Effect of Cadmium and lead in absence and presence of algae on heavy metals contentes (Cd, Pb and Cu) of spinach plants.

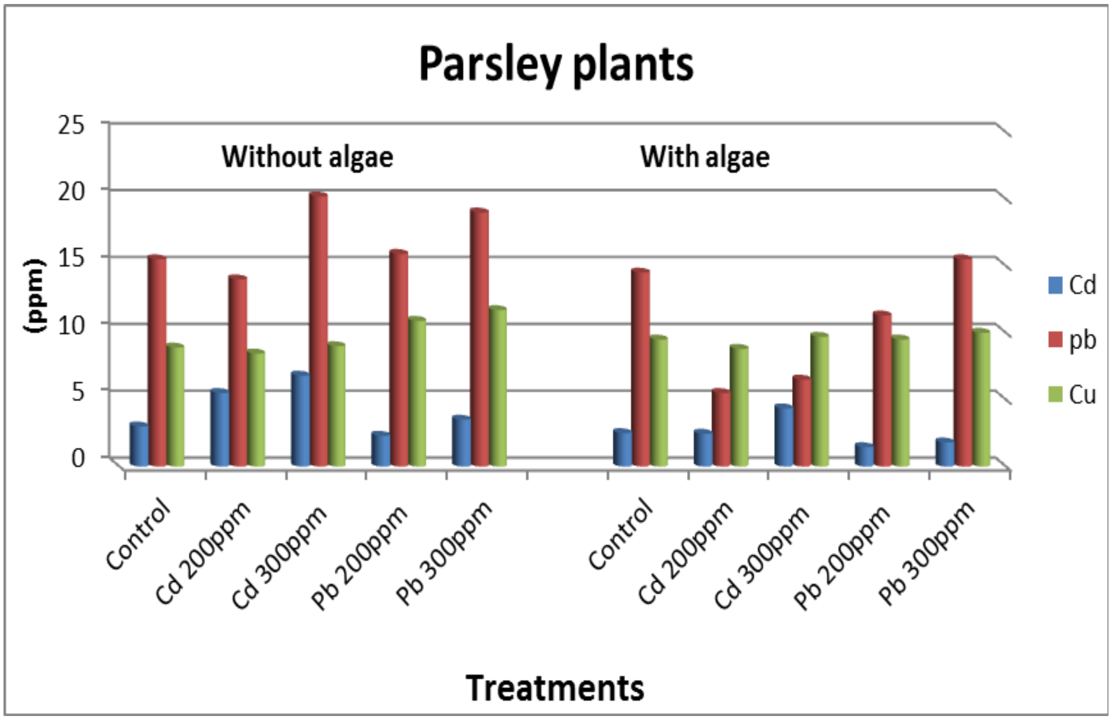

Fig. (6): Effect of Cadmium and lead in absence and presence of algae on heavy metals contentes (Cd, Pb and Cu) of parsley plants.

Lead concentration in spinach and parsley plants grown on different levels of (Cd and Pb) significantly increased by increasing lead concentration either in presence or absence of agae.

The highest values of Pb concentrations in spinach and parsley plants were recorded (19 and 17 ppm) at 300 ppm Cd without algal treatments for spinach and parsley respectively. Also, application of algae reduced polluted Pb to (15.5 and 15.4 ppm) at the same treatments for spinach and parsley plants recorded.

These results agree with **Ali *et al.* (2009) and Mahmoud *et al.*(2019)** they found that application algae reduced of heavy metals concentration in the plant. **Kaoutar and Mourad, (2013)** found that using algae or aquatic plants to remove pollutants from the environment**.** Also, **Mahmoud *et al.* (2019)** and **Kandil *et al.*, (2020)** reported that all biofertilizers treatment reduced heavy metals contents in spinach and parsley plants.

Recently, the use of aquatic plants especially micro and macro algae has received much attention due to their ability to absorption of metals and take up toxic elements from the environment or rendering them less harmful **(Matagi *et al.*, 1998).**

Several studies (**Shariatmadari et al., 2011; Koliai et al., 2012; Sokhangoy et al., 2012)** have been reported that biological fertilizers are able to change the basic nutrients lead to better seed germination, plant growth and yield. Application of biofertilizer to Cd2+ - contaminated nutrient medium resulted in an improvement of plasma membrane integrity in which increased the maintenance of *Zea* plants to absorb considerable water (increase of succulent) and macronutrients K, Ca, Mg and P, and hence increased the tolerance index.

Data show a great variation in value of Cu content in spinach or parsley as it increases with increasing levels of soil pollution under all treatments. The Cu contents in spinach decrease with algae treatment compared without algae under the same pollution level, whether with Pb or Cd, while with parsley it does not give the same effect. **Kandil *et al.*, (2020)** revealed that all biofertilizers treatment reduced Cu contents in parsley plants.

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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].

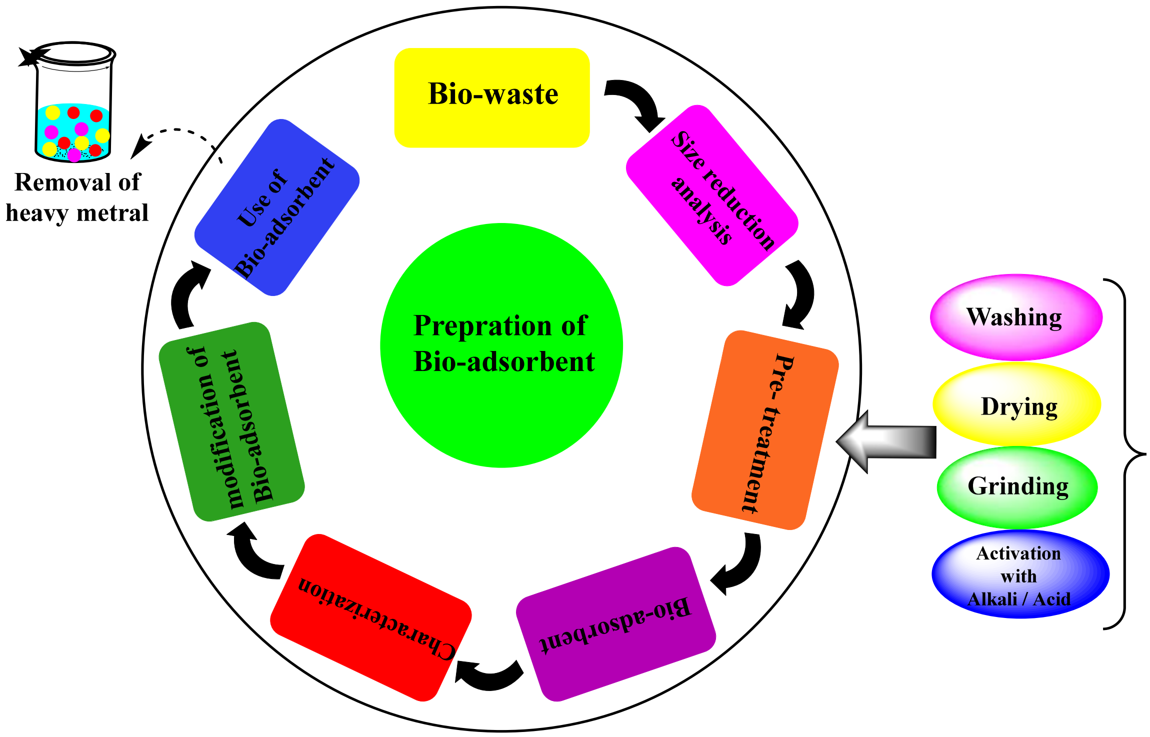


Fig 01: A common procedure for the synthesis, characterization and application of bio-adsorbents.

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).

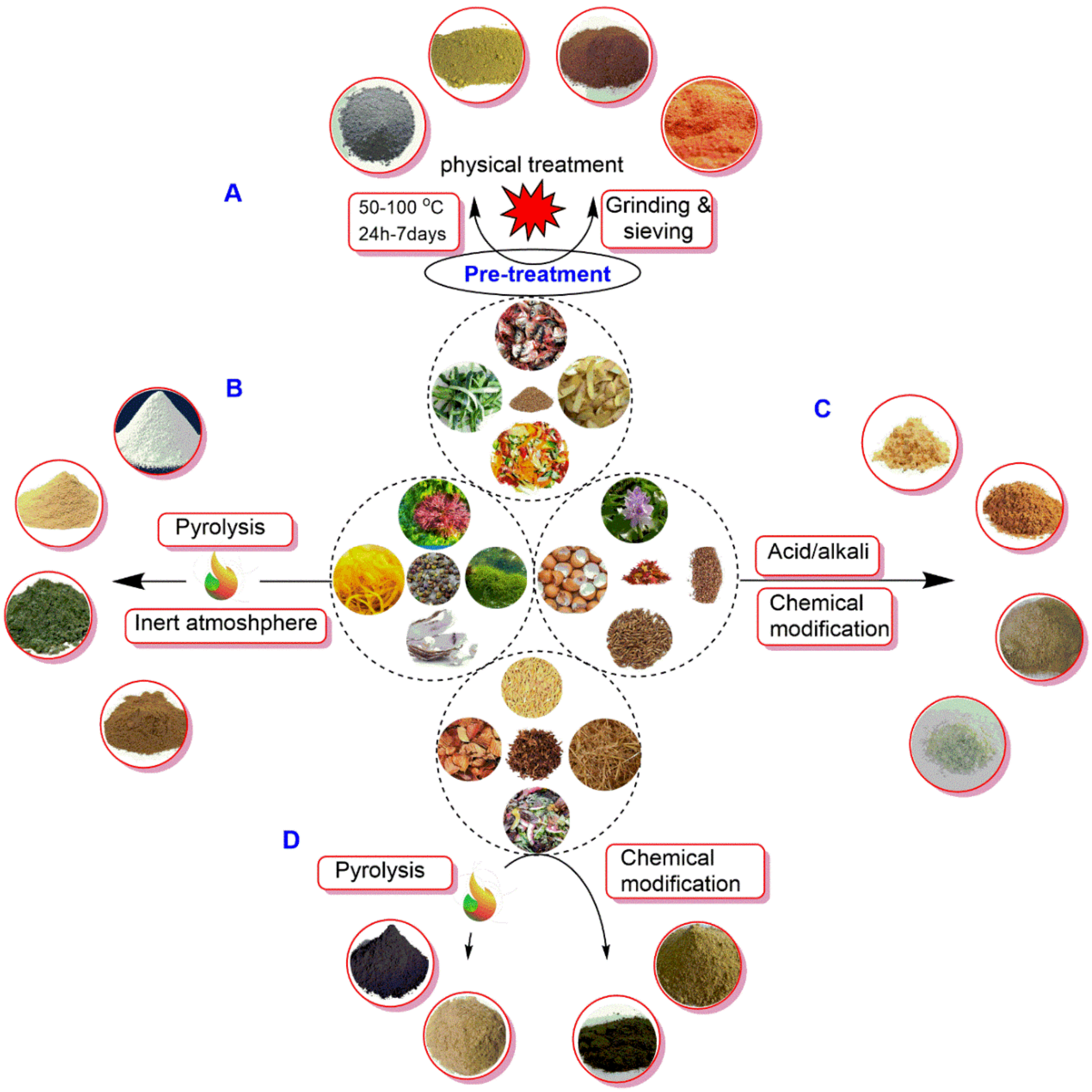


Fig 02: The most commonly used techniques of the increase of bio-adsorbents

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 (^{0}C)		
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	

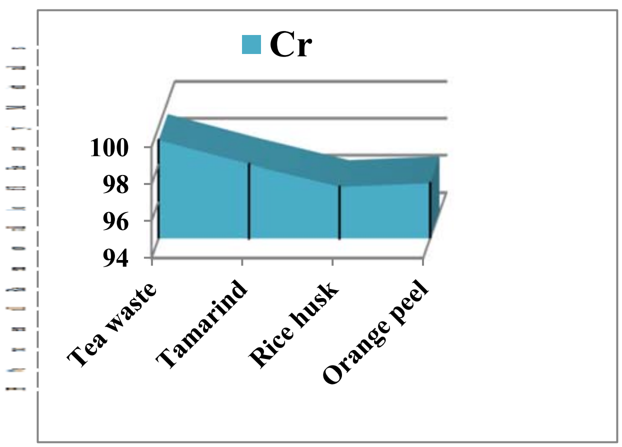
Table 05: adsorption isotherms of heavy metals on various Bio-adsorbents

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)

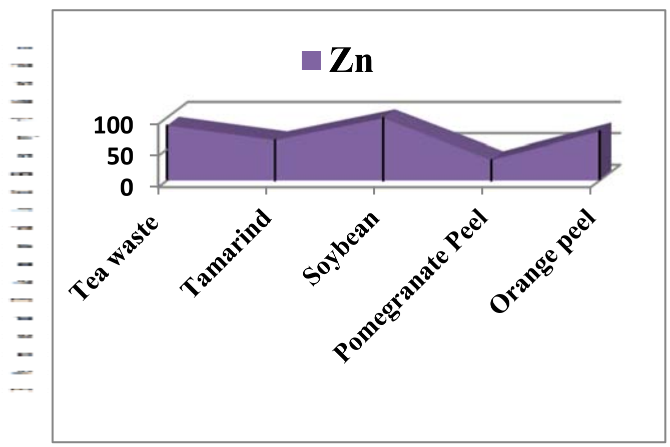
		Pb	0.5772	0.876	0.999	6.101	0.132	-	0.9576	
6.	Orange peel	Cu	2.589	6.296	0.925	40.37	0.095	-	0.996	L. (2010)
		Zn	0.37	4.21	0.95	0.76	0.72	-	0.98	XiaominLi et al.(2008)
7.	Coffee Waste	Cr	3.65	2.353	0.9810	6.961	0.1805	0.44	0.9821	W.E. Oliveira et al., 2008
		Cu	5.01	3.702	0.9025	7.496	0.4232	0.24	0.9783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

Coffee waste

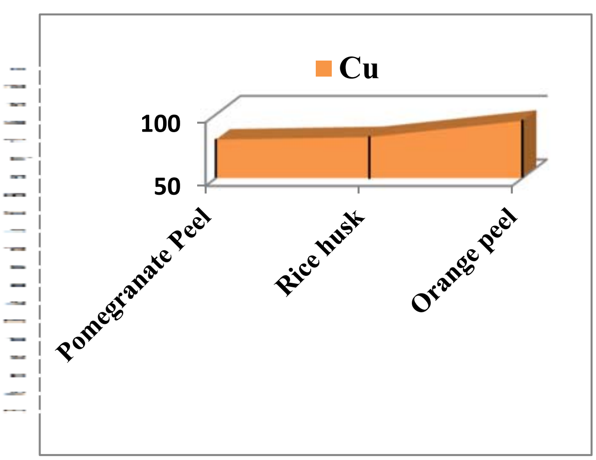
Coffee waste was taken as a Bio - adsorbent for the elimination of Cu and Zn from wastewater. Various effect of amount of bio-sorbent, type of heavy metal, and the occurrence of a different heavy metal on adsorption was observed in this experiment. In this study, the result is found that increasing the 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)



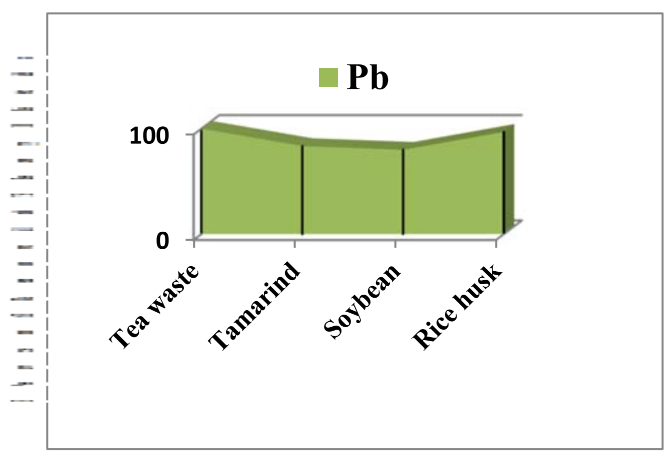
Natural Adsorbents



Natural Adsorbents



Natural Adsorbents



Natural Adsorbents

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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