EMPRO

Current Research in Pharmaceutical Sciences

Available online at www.crpsonline.com

crps online CRPS CURRENT RESEARCH IN PHARMACEUTICAL SCIENCES

ISSN 2250 – 2688

Received: 02/02/2015
Revised: 15/03/2015
Accepted: 26/03/2015

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Treatment of Toxic Pollutants from Waste Water using Novel Technique

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ABSTRACT

The toxic pollutant of water from a wide range of toxic derivatives, in particular heavy metals, aromatic molecules and dyes, is a serious environmental problem owing to their potential human toxicity. Therefore, there is a need to develop technologies that can remove toxic pollutants found in wastewaters. Among all the treatments proposed, adsorption is one of the more popular methods for the removal of pollutants from the wastewater. Adsorption is a procedure of choice for treating industrial effluents, and a useful tool for protecting the environment. In particular, adsorption on natural polymers and their derivatives are known to remove pollutants from water. The increasing number of publications on adsorption of toxic compounds by bioadsobent shows that there is a recent increasing interest in the natural of new low-cost adsorbents used in wastewater treatment. The present review shows the recent developments in the natural of adsorbents New natural based-materials are described and their advantages for the removal of pollutants from the wastewater discussed. The main objective of this review is to provide recent information about the most important features of these polymeric materials and to show the advantages gained from the use of adsorbents in waste water treatment

Keywords: Toxic element, waste water, adsorption technique, heavy metal.

1. INTRODUCTION

Water pollution is a serious problem in India as almost 70 percent of its surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic, organic, and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities, such as irrigation and industrial needs. This shows that degraded water quality can contribute to water scarcity as it limits its availability for both human use and for the ecosystem. In 1995, the Central Pollution Control Board (CPCB) identified severely polluted stretches on 18 major rivers in India. Not surprisingly, a majority of these stretches were found in and around large urban areas.

When toxic substances enter lakes, streams, rivers, oceans, and other water bodies, they get dissolved or lie suspended in water or get deposited on the bed. This results in the pollution of water whereby the quality of the water deteriorates, affecting aquatic ecosystems. Pollutants can also seep down and affect the groundwater deposits. Water pollution has many sources. The most polluting of them are the city sewage and industrial waste discharged into the rivers. The facilities to treat waste water are not adequate in any city in India. Presently, only about 10% of the waste water generated is treated; the rest is discharged as it is into our water bodies. Due to this, pollutants enter groundwater, rivers, and other water bodies. Such water, which ultimately ends up in our households, is often highly contaminated and carries disease-causing microbes. Agricultural run-off, or the water from the fields that drains into rivers, is another major water pollutant as it contains fertilizers and pesticides.[1]

Water pollution adversely affects not only aquatic plants and animals but it also affects human beings and ecosystems.

1.1 Causes of Water Pollution[2-3]

Water pollution is caused due to several reasons. Here are the few major causes of water pollution:

1.1.1 Sewage and Waste Water

Sewage, garbage and liquid waste of households, agriculture lands and factories are discharged into lakes and rivers. These wastes contain harmful chemicals and toxins which make the water poisonous for aquatic animals and plants.

1.1.2 Dumping

Dumping of solid wastes and litters in water bodies causes huge problems. Litters include glass, plastic, aluminum, styrofoam etc. Different things take different amount of time to degrade in water. They affect aquatic plants and animals.

1.1.3 Oil Pollution

Sea water gets polluted due to oil spilled from ships and tankers while traveling. The spilled oil does not dissolve in water and forms a thick sludge polluting the water.

1.1.4 Acid Rain

Acid rain is pollution of water caused by air pollution. When the acidic particles caused by air pollution in the atmosphere mix with water vapor, it results in acid rain.

1.1.5 Global Warming

Due to global warming, there is an increase in water temperature. This increase in temperature results in death of aquatic plants and animals. This also results in bleaching of coral reefs in water.

1.1.6 Industrial effluents

Industrial waste contains pollutants like asbestos, lead, mercury and petrochemicals which are extremely harmful to both people and environment. Industrial waste is discharged into lakes and rivers by using fresh water making the water contaminated. Waste water from manufacturing or chemical processes in industries contributes to water pollution. Industrial waste water usually contains specific and readily identifiable chemical compounds. During the last fifty years, the number of industries in India has grown rapidly. But water pollution is concentrated within a few subsectors, mainly in the form of toxic wastes and organic pollutants. Out of this a large portion can be traced to the processing of industrial chemicals and to the food products industry. In fact, a number of large- and medium-sized industries in the region covered by the Ganga Action Plan do not have adequate effluent treatment facilities. Most of these defaulting industries are sugar mills, distilleries, leather processing industries, and thermal power stations. Most major industries have treatment facilities for industrial effluents. But this is not the case with small-scale industries, which cannot afford enormous investments in pollution control equipment as their profit margin is very slender.

1.1.7 Eutrophication

When fresh water is artificially supplemented with nutrients, it results in an abnormal increase in the growth of water plants. This is known as eutrophication. The discharge of waste from industries, agriculture, and urban communities into water bodies generally stretches the biological capacities of aquatic systems. Chemical run-off from fields also adds nutrients to water. Excess nutrients cause the water body to become choked with organic substances and organisms. When organic matter exceeds the capacity of the micro-organisms in water that break down and recycle the organic matter, it encourages rapid growth, or blooms, of algae. When they die, the remains of the algae add to the organic wastes already in the water; eventually, the water becomes deficient in oxygen. Anaerobic organisms (those that do not require oxygen to live) then attack the organic wastes, releasing gases such as methane and hydrogen sulphide, which are harmful to the oxygen-requiring (aerobic) forms of life. The result is a foul-smelling, waste-filled body of water. This has already occurred in such places as Lake Erie and the Baltic Sea, and is a growing problem in freshwater lakes all over India. Eutrophication can produce problems such as bad tastes and odours as well as green scum algae. Also the growth of rooted plants increases, which decreases the amount of oxygen in the deepest waters of the lake. It also leads to the death of all forms of life in the water bodies.

1.2 POLLUTANTS[4]

A pollutants has been defined according to the Environmental Protection Act (EPA13) 1986 as a “a harmful solid, liquid or gaseous substance present in such condition in the environment which tends to the injurious to environment”.

On the basis of their forms which they exists in environment after their release, pollutants can be divided into following categories.

1. Primary Pollutants (Sox, NOx, CO etc)

2. Secondary pollutants i.e. substance derived from primary pollutants like Peroxy Acetyl Nitrate (PAN).

(a)Biodegradable pollutants which substance decomposed removed or consumed & thus reduce to acceptable levels e.g.domestic wastes, heat etc.

(b) Non-biodegradable pollutants: these either not degrade on very slowly or partially & there by pollute environment, Thus we can conclude that, when the waste products produce by human activity not efficiently assimilated, decomposed or otherwise removed by natural, biological or physical process than they cause adverse effect & are termed pollutants.

1.2.1 Types of pollution

Pollution may be termed as natural pollution or artificial pollution.

1. Natural pollution

Natural pollution include pollution of the environment cause due to natural process like forest fire, volcanic eruption, natural, organic and inorganic decay, earthquake etc.

2. Artificial pollution

It originates due to human activities which include industrialization, deforestation, urbanization, etc.

Pollution can be classified according to the environment (air, water, soil, noise etc) in which it occur or according to pollutants which cause the pollution.

Classification according to Environment

1. Air pollution

2. Water pollution

3. Soil pollution

Classification according to Pollutant

1. Thermal pollution, 2. Radioactive pollution, 3. Noise pollution, 4. Industrial pollution, 5. Chemical pollution, 6. Marine pollution, 7. Oil pollution, 8. Pesticide pollution, 9. Acid rain pollution, 10. Soap & detergent pollution etc

1.2.3 Lead pollution in water

Lead is naturally occurring basic element or metal. Lead pollution is the introduction of lead into atmosphere. Metallic element of atomic a number 82. Highly ductile, soft grey solid, specific gravity 11.35, melting point 327A0c,

Boiling point 175.50C, weak acid resist corrosion.

1. Source of lead pollution in water

Lead primarily comes from lead smelters, metal processing plants and incinerators. Old lead based paint is the most significant sources of lead exposure in the U.S. today, contaminated soil, dust and drinking water (5). Industrial use of lead , lead acid batteries or produces lead wires or pipes , metal recycling and foundaries, It is also potentially in drinking water, from plumbing & fixtures that are either made of lead or have lead solder. Man made source of lead include lead smelting refining, combustion of leaded fuel, production of storage battries, manufacture of alkyl lead and lead points and application of lead based pesticides. Lead pipes, Lead glazed earthenware and flaking lead points are possible source of lead in domestic environment. The predominant source of lead appears to be from the use of antiknock agents in petrol, the lead pollutes the air, fresh water & food. Erosion of natural deposits into source waters.

• Pipes

• Pipe solders

• Water fixtures in your home.

2. Health issues and Toxicity of Lead

Lead poisoning known as plumbism, celica pictonum/ saturnism/Devon colic/Painter's colic.Lead interferes with a variety of body processes aand toxic to many organ and tissues including heart ,bones, intestines, kidneys, reproductive and nervous systems.Organic lead poisoning is now very rare because countries across the world have phased out the use of arganic lead compounds as gasoline additives, but such compounds are still used in industrial settings.Organic lead compounds which across the skin & respiratory tract easily, affect the CNS predominantly.Lead is cumulative poison and their effects on human health includes GIT disorder, liver & kidney damage , infertility.Lead poisoning is due to permanent cumulative effects & not due to occasional exposure to small doses,However in extreme case of lead poisoning death may results.

3. Prevention by Lead Toxicity

Hand wash, intake of calcium and iron, elimination lead containing objects such as blinds and jwelleries. In house lead pipes and plumbing solders these should be replaced. Generally used cold water for household purposes instead of hot water. In 1978 law in US restricted the lead in paint of residences, furnitures and toys to 0.06%or less. The European Union Restriction of Hazardous substance Directives limits the amounts of Pb and other toxic substance in electronic equipment.

4. Permissible limit of Lead in water

As per WHO standards, permissible limits of lead in drinking water is 0.05mg/l.

1.2.4 Zinc pollution in water

Mettalic element, atomic numbers -30 , hard , brittle. Zinc in water produces undesirable effect and therefore the concentration of Zinc in public water supplies be less than 5.0mg/l. Water containing Zinc at concentration in excess of 5.0mg/l give an undesirable astringent tastes (WHO 1998) unsuitable for drinking and cooking purposes and develop a greasy film on boiling and therefore this value is recommended as the guidelines value, water containing 4mg/l of zinc has a bitter or astringent taste. Zinc is an essential element for human health. This deficiency in human body may results in infantilism, impaired wounds,healings and other diseases.

1. Sources of Zinc for water

• Galvinizing (55%), alloys (21%) , Brass and Bronze (16%), miscellaneous (8%).

• The metal used as anticorrosive agent. In 2009 the use, 55% ot 893 thousand lones of the zinc metal was used for galvanization. Zinc is used as anode material in batteries.

• Zinc alloy use in die casting, spin casting especially in the automotive, electrical and hardware industry.

• Zinc widely used in white pigment in paints, catalyst in the manufacture of a rubber, heat disperser for the rubber and photo copying products, fire retardant (ZnCl2), luminescent pigment (ZnS) and lasers.

• As a rust resistants coating for iron and steel products.

• In the manufacture of brasses and bronze in the die-casting industry.

• As ingredients of many household items utensils, powders , cosmetics, ointments, antiseptics ,paints, varnishes and others.

• In the manufacture of parchment papers, glass, automobile tiles,Tv screens,dry cell batteries,electrical apparatus, insecticides, printingand dying of tiles,in metallurgical operation,wood preservatives.

• As a medicine.

2. Causes of Zinc pollution in water

Corrosion of galvanized pipes by soft acidic water. Zinc is used in fertilizers and may be found in landfill lechate or industrial wastes .Found naturally in water,most frequently in areas where it is mined. Enters environment from industrial waste, metal planting and plumbing and is major component of sludge.

3. Health issues and toxicity of Zinc

• Swallowing a one percent piece (97.5%) of zinc can cause damage to stomach lining due to high solubility of zinc ions in the acidic stomach.

• Induced copper deficiency at low intake of 100-300mg Zn/day.

• Levels of zinc in excess of 500 ppm in soil interfere with ability of plant to absorb other essential metals, such as iron and Mn.

• The U.S.Food and Drug administration (FDA) has stated that Zn damages nerves receptors in the nose, which can cause anosmia. On june 16,2009,the FDA said that consumers should stop Zn based intrannsal cold products and ordered their removal from storage shelves.FDA said loss of smell can be life threading.

• Recent Research suggests that the topical antimicrobial Zinc pyrithione is a potent heat shock response inducer that may impair genomic integrity with induction of PARP- dependent energy crisis in cultured human keratinocytes and melanocytes.

• Heamolytic anemia, liver and kidney damage, vomiting, diarrhea.

• Zn is highly toxic for parrots and poisoning can often be fatal.

• Acute adverse effects of high Zinc intake include nausea, vomiting loss, of appetite, abdominal cramps, diarrhea, and headache. Intake off 150-450mg of Zinc per day have been associated with such chrome effect as low copper status, altered iron functions reduced immune system reduced levels of high density in lipoproteins.

4. Permissible limilt of Zinc in water

The current OSHA standard for Zn is 5 mg. The WHO permissible level of Zinc is 5.0 mg/l.

1.3 Effects of Water Pollution[2-3]

The effects of water pollution are not only devastating to people but also to animals, fish, and birds. Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It diminishes the aesthetic quality of lakes and rivers. More seriously, contaminated water destroys aquatic life and reduces its reproductive ability. Eventually, it is a hazard to human health. Nobody can escape the effects of water pollution.

The individual and the community can help minimize water pollution. By simple housekeeping and management practices the amount of waste generated can be minimized.

1.4 Types of Water Pollutants

The undesirable elements responsible for water pollution can be categorized as given below

1. Physical pollutants

2. Chemical pollutants

These types of pollutants are generally most harmful to human and aquatic organism and may be classified into two groups.

(a) Inorganic pollutants

Inorganic substances such as acids, alkalies, metallic salts, minerals, finely divided metals, metal compounds, complexes of metals, organometallic compounds, phosphate, nitrate, sulphate, sulphites, bi-carbonates, chlorine, fluorine, hydrogen sulphide, trace elements, etc. are major pollutants of this type.

(b) Organic pollutants

Organic pollutants are mainly oils, plant nutrients, dyes, and chlorinated hydrocarbons, oxygen demanding wastes, phenols, herbicides, pesticides, detergents, carboxylic acids, sewage and synthetic organic compounds including dyes.

1.4.3 Biological pollutants

Bacterial, protozoa, algae, fungi, viruses, aquatic weeds, disease producing parasitic worms are some of the major biological pollutants.

1.4.4 Radio-Active pollutants

Liquid and gaseous wastes from fuel, low level radioactive wastes, elements, various components of radioactive fallout, radio nucleocides, fission products, etc. are the main radioactive pollutants.

1.4.5 Heat

The increase in temperature of water by any means decreases the dissolved oxygen of water which affects fish and other aquatic life adversely. The quality of surface and ground water is adversely affected by greater input of above pollutants. The principal contributors are industrial and municipal wastes. The extent of the water contamination by different types of pollutants causes the change in the ecology of the environment.

1.5 Water and Wastewater Treatment Methods

A variety of treatment techniques have been developed in the past for the removal of different types of pollutants from water and wastewater. However, it is pertinent to take into account all the capital and operating costs, the land requirement and other specific needs of every possible method of treatment before a final choice can be made. Different techniques employed for the removal of pollutants from water and wastewater can be divided into four groups:

1.5.1 Physical Methods [5-8]

Sedimentation[5], floatation[6], filtration[7] and membrane separation techniques have been employed for the removal of physical pollutants from water. The removal of a large number of suspended particles like clay, sand particles, gravel, etc. may be accomplished by sedimentation, whereas, flotation method has been adopted for the removal of suspended and colloidal impurities by bubbling the solution. Solid and biological flocs present in surface water are removed by filtration method. The use of semi permeable membranes [8] is a recent addition to the technology of water purification. This includes reserve osmosis, ultra filtration and electro dialysis.

1.5.2 Chemical Methods [9-13]

Depending upon the nature of water pollution from various sources, chemical methods like reduction, precipitation, chemical coagulation, ion exchange and adsorption have been successfully used to improve the quality of water. The reduction and precipitation are generally used for the removal of toxic metallic species of wastewaters. The coagulation process for the removal of toxic metallic species of wastewaters. The coagulation process for the removal of toxicants consists of separation by aggregation of small particles into large ones which are more readily settled. Ion-exchange method is generally used to remove the ionic species from water and wastewater. The removal and recovery of radioactive materials from the wastewaters of nuclear reactors, hospitals and laboratories are possible by ion exchange method. These days, the adsorption technique for the removal of pollutants from water is becoming more popular due to the factor that the technique is quite simple and relatively less expensive. The use of activated carbon for the wastewater treatment has been well established as a practically reliable process, especially for the treatment of organic contaminants due to their organophillic character. In addition to these, the removal of pollutants from water by electrode position, sedimentation, solvent extraction, ion floatation and freeze concentration processes are also employed.

1.5.3 Biological Methods [14-16]

These methods have been developed on the basis of the ability of various marine organisms to accumulate trace elements and various types of organic pollutants. The most common biological methods are activated sludge process, aerobic, anaerobic digestions, aerated lagoons process and oxidation ponds etc.

1.5.4 Integrated Methods[17]

In the recent years, the scientists have developed a new integrated method for purification of water by combining any two or all of the three methods mentioned above. The integrated methods may be classified as bio-chemical, bio-physical and bio-physico-chemical methods.

Among all the methods described above, the adsorption method is generally preferred for the treatment of polluted water due to its high efficiency, easy handling and less expansiveness. Therefore, in the present work the adsorption method has been examined for its feasibility for the removal of certain metals from water.

1.6 Heavy Metal Contamination and Toxicity

Heavy Metal Contamination is a general term given to describe a condition having abnormally high levels of toxic metals in the environment. Heavy metals are subtle, silent, stalking killers. It has been realized that sometimes the natural cycles can pose a hazard to human health because the level of heavy-metals exceed the body's ability to cope with them. The situation becomes worst by the addition of heavy-metals to the environment as a result of both the rapidly expanding industrial and domestic activities. The metals are introduced into the environment during mining, refining of ores, and combustion of fossil fuels, industrial processes and the disposal of industrial and domestic wastes18. Human activities also create situations in which the heavy-metals are incorporated into new compounds and may be spread worldwide[19]. Many aquatic environments face metal concentrations that exceed water 12 criteria designed to protect the environment, animals and humans. Every essential element is toxic if taken in excess and there is a safe window for essential dose between deficiency and toxicity. Some elements such as Ca and Mg have wide window whereas others such as Se and F have narrow window where by an excess will rapidly lead to toxicity and death. Metal toxicity can be divided into three categories i.e. blocking the essential biological functional groups of molecules, displacing the essential metal ion in biomolecules and modifying the active conformation of biomolecules [20].

The toxicity effects greatly depend on the bioavailability of the toxicant meaning the proportion of the contaminant present in the environment in the form(s) that can be assimilated by organism[21]. The health hazards presented by heavy-metals depend on the level of exposure and the length of exposure. In general, exposures are divided into two classes: acute exposure and chronic exposure. Acute exposure refers to contact with a large amount of the heavy-metal in a short period of time. In some cases the health effects are immediately apparent; in others the effects are delayed. Chronic exposure refers to contact with low levels of heavy-metal over a long period of time[19].

Table 1: Important sources of metal pollutant

Metal	**Source**	**Metal**	**Source**
Be	Fluorescent lamps	Se	Glass, photocells
Os	Catalyst, staining agent	Cd	Cladding alloy, alkali cells
Pt	Catalyst, alloy, thermocouple	Pb	Auto-exhaust emission, water pipes
Hg	Chloroalkali industry, pesticides	As	Paper pulp industry pesticides
TI	Rodenticide; pesticides	Sb	Alloys, pharmaceuticals preparations.
V	Furnace oil, metal mills	Cr	Plating industry, paints, alloys
Te	Auto-exhaust emission	Ni	Alkaline cell, alloys, catalyst
Co	Ink pigment, magnets	Zn	Galvanization, alloys
U	Nuclear reactors	Mn	Mines, minerals

Table 2: Pathological effects of metal water pollutants on man

Metal	Pathological effects on man
Lead (Pb)	Anemia, vomiting, loss of appetite, convulsions, damage of liver, brain and kidney
Arsenic (As)	Disturbed peripheral circulation, mental disturbance, liver cirrhosis, hyperkeratosis, lung cancer, ulcers in gastro-intestinal tract, kidney damage
Mercury (Hg)	Abdominal pain, headache, diarrhea, chest pain, hemolysis

Cadmium (Cd)	Growth retardation, diarrhea, bone deformation, kidney damage, anemia, injury of central nervous system, hypertension, injury to liver
Barium (Ba)	Excessive salivation, vomiting, diarrhea, paralysis, colic pain
Cobalt (Co)	Diarrhea, low blood pressure, lung irritation, bone deformation, paralysis
Chromium (Cr)	Gastrointestinal ulceration, disease in central nervous system, cancer, nephritis
Selenium (Se)	Damage of liver, kidney and spleen, fever, nervousness, vomiting, low blood pressure, blindness and even death
Zinc (Zn)	Vomiting, cramps, renal damage
Copper (Cu)	Sporadic fever, hypertension, uremia, coma

7.1 BIOSORBENTS [22-23]

Biosorption can be defined as the removal of metal or metalloid species, compounds and particulates from solution by biological material. Large quantities of metals can be accumulated by a variety of processes dependent and independent on metabolism. Both living and dead biomass as well as cellular products such as polysaccharides can be used for metal removal.

The tested biosorbents can be basically classified into the following categories:

a) bacteria (e.g. Bacillus subtillis),
b) fungi (e.g. Rhizopus arrhizus),
c) yeast (e.g., Saccharomyces cerevisiae),
d) algae,
e) industrial wastes (e.g., S. cerevisiae waste biomass from fermentation and food industry),
✓ agricultural wastes (e.g. corn core) and
✓ other polysaccharide materials, etc.

10.2 Bioadsorbents and its characteristics[24]

For removal of heavy metal from wastewater, bioadsorbent are being used these days should have following characteristics

- Metal binding capacity
- Pectin carboxyl group play a major role in metal binding capacity.
- Based on binding mechanism pH and ionic strength effects on biosorption.
- Sorbent should follow of low cost method for processing the process of biosorption.
- Sorbent should be stable for multiple adsorption/desorption cycle.
- Develop a low cost method for processing the raw waste materials, high performing bioadsorbent (it means transportation cost usage of energy can be minimized by using locally collected biomass as the basis for a bioadsorbent system)
- Ideal bioadsorbent should be very cheap unwanted byproduct that currently has to be hauled away and land filled or burnt in heaps (bioreasource.com)
- Kinetically favorable/kinetics favorable modeling kinetics.
- Economically feasible.
- Perform an economic analysis and feasibility study for industrial application.
- FTIR spectra show the shifting in the peak of carboxyl group after metal binding, demonstrating these role of these group.
- Increasing metal binding capacity with increasing pH
- Local availability of large quantities- It is essential factor prompting in use of bioadsorbent technology (gupta *et al.,* 2000). It emphasis on sufficient attention to operating costs, including the costs of transporting the sorbent materials to the point of use , (gadd 2009) suggested that the composition of biomass remain same everywhere so not to waste lot of efforts in testing the representative of biomass. [25- 28]

Amongst all the treatments proposed, adsorption using sorbents is one of the most popular methods since proper design of the adsorption process will produce high-quality treated effluents. Adsorption is a well-known equilibrium separation process. It is now recognized as an effective, efficient and economic method for water decontamination applications and for separation analytical purposes. The adsorbents may be of mineral, organic or biological origin: activated carbons[43-48] , zeolites[49,50] , clays[51-55], silica beads[56,57], low-cost adsorbents (industrial by-products[58-63], agricultural wastes[64,65], biomass [66,67] and polymeric materials (organic polymeric resins [68,69], macroporous ypercrosslinked polymers[70,71]) are significant examples

Table 3: Natural product used as bioadsobent for removal of heavy metal

Bioadsobent (Natural Product)	**Metal**	**Adsorbent capacity (Mg/g)/Efficiency (%)**	**refer ence**
Black tea leaves	Cr (IV)	364 mg/g	29
Coca shell	Pb,Cr,Cd,Cu,Fe,Zn,Co,Mn,Ni,Al	Pb95,Cr53,Cd81, Cu70,Fe45,Zn64, Co57,Mn53,Ni50, Al15(%)	30
Coconut copra meal	Cd	1.70mg/g	31
Coconut shell carbon	Zn	90%	32
Coffee bean	Pb(II), Cr(II), Cd(II), Cu(II), Fe(III), Zn,II	5.98×10^{-2}mmol/g	33
Crab shell	Cu Co	243.9mg/g 322.6mg/g	34
Egg shell	Cr (III)	160mg/g	35
Husk of bengal shell	Cr (IV)	99%	36
Husk of black shell	Pb,Cd,Cu,Zn,Ni	49.97,39.99,33.81, 25.73,19.56(mg/g)	37
Pappya wood	Pb,Cd,Cu,Zn,Ni	97.8,94.9,66.8(%)	38
Sugerbeet pulp	Cu (III)	28.5mg/g	39
Sunflower stem	Cr (III)	85%	40
Waste fruit residue	Hg (II), Pb(II), Cd(II), Cu(II), Zn,(II), Ni (II)	Hg85,Pb90,Cd86, Cu96,Zn87,Ni85(%)	41
Wheat shell	Cu (II)	99%	42

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