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Efficient bio adsorbents for removal of heavy metals from water: A review

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Abstract
Due to globalisation water quality is decreasing day by day. Water get contaminated due to number of factors, among these heavy metals are the biggest problem whose major sources are various type of industries like electroplating, tanning, refinery etc. Heavy metal contamination in water lead to severe diseases in human beings. So, it is the need of an hour to purify the water to make it fit for the consumption. A number of physical, chemical, biological methods are reported for purification of water but all have some sort of disadvantages like disposal problem, expensive, not ecofriendly etc. Bio sorption technique has overcome all these issues and come up with 45-96% results. Fruit and vegetable peels are employed as bio adsorbents and work efficiently in this technique. These bio adsorbents are very cheap, easy and safer to use. However, there is a need for extending this laboratory scale work to pilot plant scale so that the costly bio adsorbents can be replaced with these low cost bio adsorbents.

Keywords: Ecofriendly water purification, Bio adsorbents, fruit and vegetable peel, heavy metal pollutants, waste water

Introduction
Water is the most ubiquitous liquid on our planet which is vital to all life forms. Although water is available in plenty but according to today's scenario, availability of pure drinking water has decreased due to number of factors. Due to industrialisation and urbanisation various toxins are discharged directly in rivers causing water pollution [1]. Heavy metals are major toxic pollutants with severe health effects on humans. Cadmium, lead, zinc, chromium, copper are the most toxic metals of various use in industries such as chemical processing, electoplating, tanning etc. There have been many examples where heavy metals when present in large concentrations prove harmful to mankind and environment [2]. Therefore it is the need of an hour to purify the water to make it fit for the use. A number of techniques are available for the purification of water which are divided in to three types namely physical, chemical and biological. All these methods have some kind of demerits like high cost, not ecofriendly and disposal problems. So, there is a requirement for some alternative method which can overcome all these problems and treat the waste water in an appropriate manner.
Bio-technique has attracted much attention due to its environment benign and green nature. Biosorption can be defined as ability of biological materials to accumulate heavy metals from waste water [3]. Bio sorption also offers low operating cost, minimisation of chemicals and there is no additional requirement of nutrients [4]. Several bio adsorbents have been used for heavy metals removal like banana peels, orange peels, potato peels, pomegranate peels, kiwi peels, tomato peels, pumpkin peels etc.it has been found that orange and banana peels are the most extensively studied adsorbents. The use of bio adsorbents is very simple and moreover they are cost effective. In this paper a review of various bio adsorbents which include fruit and vegetable peels have been presented along with which bio adsorbent is suitable for removal of which metal.

Conventional Methods for Water Purification
Conventional methods employed in water purification are sedimentation, filtration, coagulation, flocculation and chlorine [5]. For purification of drinking water mostly techniques used systems which uses filtration techniques, wide range of adsorbents and disinfection methods. Latest technologies use nanoparticles etc. which are given in table-1.

Table 1:

Filtration techniques	Polymer and nanotechnology	Electrical techniques	Disinfection techniques	Adsorbent materials
Membrane techniques	Nano particles	Electro dialysis	Sonication	Zeolites
Micro filtration	Nano tubes	Electro floatation	UV radiation	Activated carbon
Ultra filtration	Nanocomposites	Electrochemical method	Solar energy	Ferric hydroxide
Nano filtration	Thin films	Electro coagulation	Photo catalysis	Ceramics

Impact of Heavy Metals on Human Health

Heavy metals occurrence in the environment, their toxicity, health hazards and the methods used for analysis has been studied by various authors. Long term drinking water exposure of arsenic causes skin, kidney problem, nausea, neurological disorders [6-8]. Presence of copper in drinking water can cause renal damage, mucosal irritation and central nervous problem in humans. Cadmium existence causes lung cancer, kidney damage, nausea, haemorrhage, severe diarrhoea. Lead existence can cause headache, abdominal pain, and nervous system problem. Lead poisoning in children may cause abnormality in their behaviour, reduced intellectual capacity etc. Long term exposure to heavy metals such as arsenic, copper, cadmium, nickel, zinc can cause detrimental effects on human health. Other less common metal contaminants include cobalt, strontium, uranium, molybdenum, and caesium.

Use of Bio Adsorbents (Fruit and Vegetables Peels) In Water Purification

Today removal of heavy metals from water is a challenging problem and it can be achieved by various methods. The existing methods for waste water treatment have many problems like they are uneconomical, it consumes lot of space, commercially they are unattractive and disposal problems. So there was a requirement for some another technique which can overcome all these problems in an appropriate manner. Biosorption has solved this problem in very good way and come out with excellent results. These bio adsorbents are purely based on the aim to achieve environmental sustainability by using household waste such as banana peels, orange peels, potato peels, pomegranate peels, kiwi peels, tomato peels, pumpkin peels etc. which are cheap, easily available and a very effective adsorbent. Banana peels are good adsorbents and very successful method in water purification because banana peels contain nitrogen atoms, sulphur and carboxylic acids.

Agricultural "waste peels" as low-cost biosorbents for water purification

These groups are negatively charged so that they can bind with positively charged metals in the water [9, 10]. Adsorption on fruit and vegetable peel waste depends on various factors like PH of the solution, temperature, speed of agitation, particle size of peel waste, contact time, adsorbent dose and initial adsorbate concentration. Fruit and vegetables peels waste are characterised by FTIR,SEM(scanning electron microscopy), nuclear magnetic resonance (NMR), TEM (transmission electron microscopy), X-ray diffraction, BET (brunauer Emmett teller), energy dispersive X-ray(EDS), thermo gravimetric analysis (TGA) etc.

Pomegranate peel bio adsorbent was studied and found to be best adsorbent for removal of Fe(II)from aqueous solution and adsorption was exothermic and spontaneous [11]. Orange peels are used for removal of Ni (II) from electroplating waste water. Authors also studied the orange peel capacity to eliminate lead, copper, zinc from water. The adsorption follows the order Ni (II)>Cu (II)>Zn (II)>Cr (II) [12]. The adsorption process is endothermic. Bio adsorbent prepared from banana peels has been reported for the removal of chromium, cadmium and copper ions from aqueous solution [13]. Pine apple peel bio adsorbents are used for removal of sofranin-O from aqueous solution [14]. So, these fruits and vegetable peels can be used for removal of heavy metals from industrial waste water generating waste water with low volume and lower concentration as pre-treatment before secondary treatment. In the following table it has been listed that which peel is suitable for removal of which metal from water and at what temperature and PH [15]

Table 2.

1.	**Orange peel**	**Ni, Cr, Zn, Pb, Cu**	**96**	**6**	**50**
2.	Banana peel	Pb(II)	74	7	-
3.	Pomegranate peel	Fe(II)	-	6	29
4.	Pine apple peel	Sofranin-O	43	-	29
5.	Pumpkin peel	Pb(II)	74	7	-
6.	Tomato peel	Co(II)	99.6	8	30

Method To Use Fruit &Vegetable Peels As Bio Adsorbent

Raw fruit, vegetable peel waste as bio adsorbent arises numerous problems like less adsorption power, high BOD, high COD, high total organic carbon (TOC) because of leaching of dissolved organic compounds present in the peel waste. So, it should be given prior treatment before use because it can alter its physical, chemical properties and also its adsorption power. Different methods are listed in the literature for treatment. Physical treatment includes cleaning, drying and thermal treatment. A chemical method involves pyrolysis, decaroxylation, polymerisation, xanthanation, protonation, saponification, deamination etc. A flow chart diagram for pre-treatment of bio adsorbent is shown in figure 1 [16]

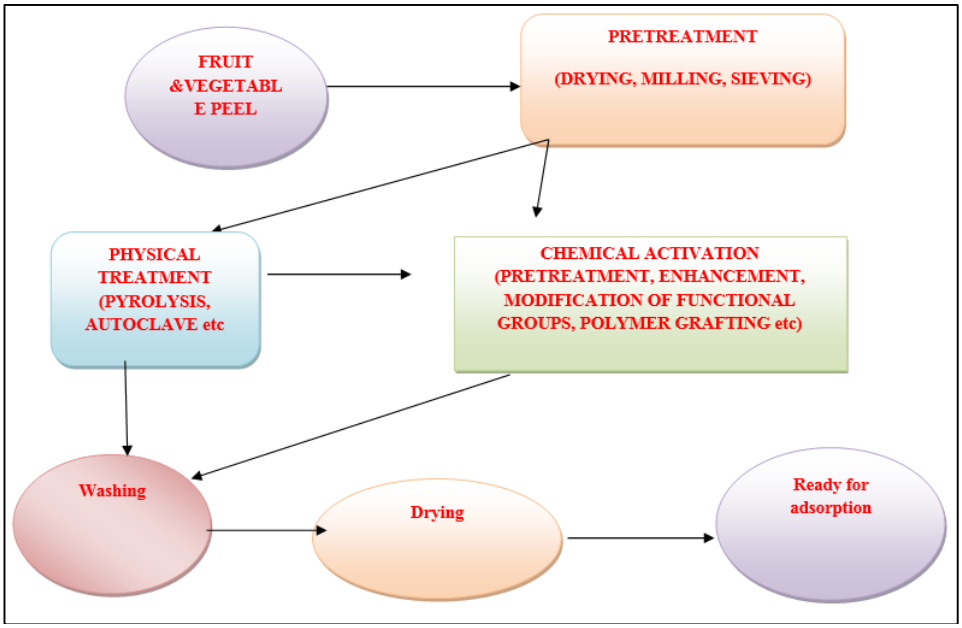

Fig 1.

Regeneration of Adsorbent

Its a process in which adsorbent loaded peel waste are eluted by using proper solvent to recover pollutants. The significance of any bio adsorbent depends not only on its adsorption power but also on its regeneration capacity. The adsorbate can be recovered by using various physical, chemical methods. It has been found that desorption mechanism is similar to adsorption mechanism. Figure 2 shows schematic flow diagram of regeneration process [16].

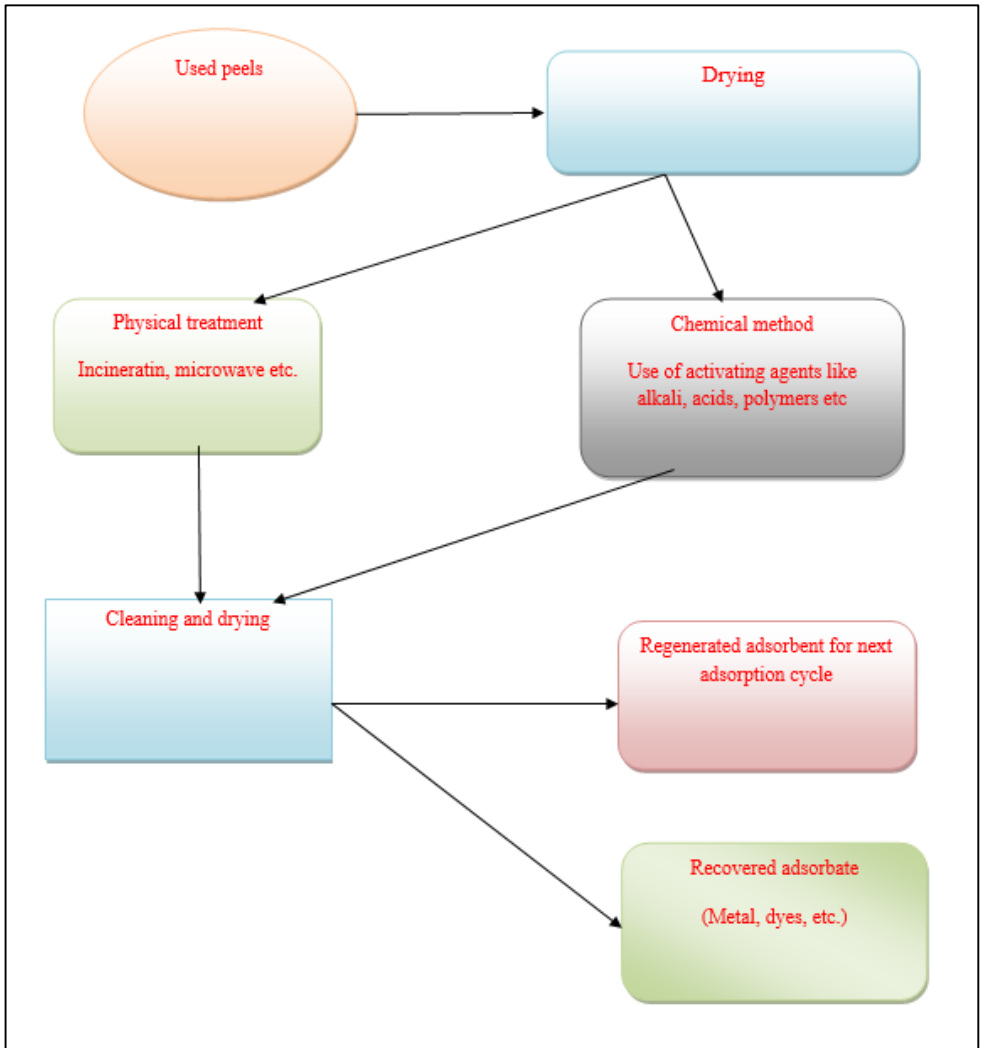

Fig 2.

Conclusions

These cost effective bio sorbents are very useful for pre-treatment of waste water. The efficiency of these fruit and vegetable peels is from 45% to 96%.These low cost bio adsorbents are economically cheaper and easily available making this process very sustainable. This green method can be highly recommended for domestic drinking water purification and this can also be applied for water purification in developing countries where people used to drink contaminated water. This will also

Improve both health and wealth. There is a need for extending the laboratory scale work to pilot plant scale so that expensive bio adsorbents can be replaced with these low cost bio adsorbents.

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