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Analysis and comparison of adsorption properties of cadmium micropollutant present in wastewater by biochar and water hyacinth

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Abstract

Micropollutants are a growing concern regarding contamination of groundwater resources. Heavy metals such as cadmium are steadily increasing in concentration in various natural water sources. These heavy metals seep into drinking water and is very difficult to remove via normal commercially available filtration methods. These pollutants are non biodegradable; implying that they accumulate in living tissue which leads to the problem of biomagnification. Thus, they possess a threat to the ecosystem. Existing treatment methods in wastewater plants are insufficient to remove heavy metals. There is a significant need to invent cheap and effective methods for micropollutant/heavy metal removal. These methods should also preferably use biological agents instead of chemical ones. In this work, the adsorption of cadmium in biochar and water hyacinth has been analysed and compared.

Keywords: Biochar, adsorption, cadmium, micropollutant

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1. Introduction

As water is used in number of purposes such a for drinking, daily life activities, household work, different sectors such as agriculture, irrigation and in different industries for manufacture of desired products, thus it is considered as one of the basic need for life on the planet earth [1]. Water is used in number of different industries, pharmaceutical manufacturing plants and the waste containing toxic elements or pollutants from these industries are discarded directly in the water bodies resulting in the increase concentration of these pollutants in the water bodies. The increased concentration of these toxic elements or pollutants cause adverse effect to the environment and harmful to the aquatic life as well as humans and animals [1].Number of different micropollutants are observed in water bodies from previous few years such as PPCP (Pharmaceutical and personal care products), organic compounds , compounds which disrupt endocrine system, pesticides etc. [1]

Existing waste water treatment plants are not specifically designed to remove the micro pollutants which are present in the waste water [2], therefore the waste water is considered as major source of the discharge of these chemicals in the environment [3]. Nowadays, organic micropollutants are occurring in increasing concentrations in groundwater and other water sources. This is steadily escalating to become an environmental issue. The occurrence and continuous input of organic micro pollutants in receiving waters including groundwater is a growing environmental issue. As micropollutants are known to be non-biodegradable (cannot be degraded by the natural agents), persistent and bioaccumulative, many of them have been identified as potential threats to aquatic species and animals and probably to human health. Number of micropollutants and metabolites of these micropollutants in the waste water are

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removed insufficiently from the existing plants for treatment of waste water (WWTPs) since micropollutants are poorly biodegradable in the existing waste water treatment processes [4] .

Number of Dairy industries produces wastewater in huge volume which contains high organic load having proteins, amino acids, carbohydrates, phosphates and metals as well as untreated raw materials such as untreated milk, cream, cheese and icecream . Wastewater from some of these industries contains heavy metals and has been proved challenging for conventional treatment processes [5] . Heavy metals like Lead (Pb), Arsenic (As), Cadmium (Cd) and Mercury (Hg) are present in the environment in different forms which adversely disturbs the

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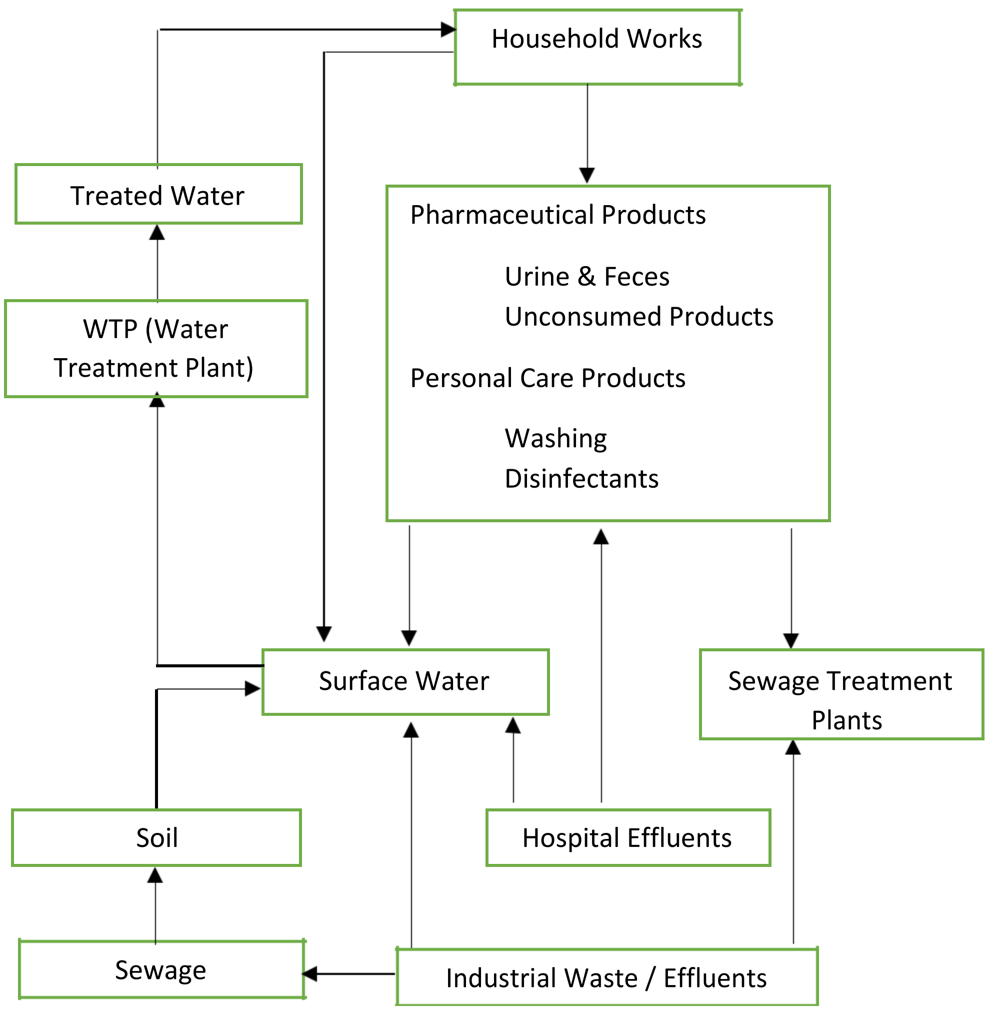
aquatic life as well as affects the health of humans and animals on the basis amount of dose of heavy metals and duration of exposure . These heavy metals are present in water bodies and food cycle thus administered in human body and affects the health of humans depending on amount of dose and duration of exposure [6]. Heavy metals are toxic for human body as they can accumulate in different organs such as kidney, liver , heart , brain and disturbs the metabolic processes of the body .Number of health effects are associated with heavy metals such as damage of organs, kidney damage, neurotoxic effects, cancer risk ,diabetes risk etc depending on level of exposure and duration of exposure [7].



Flow chart: Pathway and sources of micropollutants

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Cadmium (Cd) is a heavy metal which is generally present in the form of ores in nature. Cadmium is used as stabilizer in different products such as color pigments, alloys and in products related to Polyvinyl chloride (PVC). Phosphate fertilizers also contain Cd in significant amount. Incineration of waste containing Cd also poses a problem, as it pollutes the air and water bodies. Number of health effects are associated with cadmium such as kidney damage, Risk of cancer, Neurotoxic effect, Respiratory problems, Bone demineralization, Effect on Reproduction, Diabetes risk [8] .

As heavy metals are insufficiently removed from waste water in conventional waste water treatment plants, number of research has been done using different techniques such as chromatography , adsorption, membrane filtration. In recent times the application of adsorption technique has attracted interest [9] .Adsorption process is done using adsorbent . Different materials can be used as adsorbent in this process such as plant leftovers, rise husk, biochar for example sludge biochar, plant roots (Water hyacinth), activated carbon for example powder activated carbon (PAC) or granulated activated carbon (GAC). Biochar prepared from sewage sludge and water hyacinth plant is an effective adsorbent used in the adsorption process. Biochar is used as an adsorbent in this process because of different properties such as high surface area and pore volume. As far as metal ions are concerned, Biochar has a significant affinity because of physical adsorption of the ions on its surface [10].

Biochar is basically a carbon rich solid material which is formed by biomass pyrolysis. It is low cost method to remove contaminants present in the water. Biochar and its derivatives has the capacity to adsorb various contaminants present in water such as heavy metals , synthetic organics , pathogenic organisms [11].

Use of Eichhornia crassipes plant part as adsorbent in adsorption process. Eicchornia crassipes also known as water hyacinth has drawn attention for removal of contaminants such as toxic metal ions or heavy metals. The material obtained from plant such as biochar , activated carbon, dried roots, plant ash can be used as adsorbent for removal of contaminants [12].

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Table 1: Types of micropollutants present in the environment

Types of micropollutants	Reference
1.Pharmaceuticals	[2] , [13]
1.a Antibiotics	
1.b Hormones	
1.c Anti-inflammatory drugs	
1.d Analgesics	
1.e Blood lipid regulator	
2. Personal care products	
2.a Bactericides/disinfectants	
2.b Preservatives	
2.c Insect repellents	
2.d Fragrances	
3.Endocrine disrupting compounds	[13]
3.a Natural and synthetic hormone	
3.b Alkyl phenols	
3.c Polycyclic aromatic hydrocarbons	
4. Perfluorinated compounds	
5.Other organic compounds Such as sucralose, cyclamate ,plasticizer and surfactants	

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2. LITERATURE REVIEW

2.1. OCCURRENCE OF MICROPOLLUTANTS IN ENVIRONMENT

2.1.1. Occurrence of pharmaceutical and personal care products in environment

Various pharmaceutical and personal care products are present in the water. Pharmaceutical products include Antibiotics, anti-inflammatory drugs, analgesics, anti-viral drugs , hormones and blood lipid regulators . Personal care products includes various preservatives, fragrances, bactericides , disinfectants. . Pharmaceuticals are used for treatment and prevention of diseases in the humas and animals but if these are taken in extreme amount results in sickness [14]. PPCPs can enter the water or environment through number of different pathways such as Sewage treatment plant (STPs), industrial and hospital effluents, Water treatment plants (WTPs) , domestic effluents. PPCPs present in Surface water and ground water [15] , Sewage treatment plants (STPs) , Water treatment plants (WTPs) [16] are very harmful for humans , animals as well as aquatic life. Conventional existing (STPs) sewage treatment plants processes which includes various steps such as 1.screening 2. Degritting 3. Primary sedimentation 4. Aeration tanks 5. Final sedimentation are not efficient in removing the PPCPs present in the sewage. Some PPCPs present in the sewage can be eliminated from the sewage , but most of the PPCPs are not removed on conventional sewage treatment plants. One of the possible method for control of PPCPs contamination is use of activated carbon such as Biochar, Granular activated carbon (GAC) and Powdered activated carbon (PAC). Biochar is a carbon rich solid material which is formed by pyrolysis of biomass is low cost method to remove contaminants present in the water. Biochar and its derivatives has the capacity to adsorb various contaminants present in water such as synthetic organics, heavy metals, pathogenic organism [17]. Granular activated carbon and powdered activated carbon has capacity to adsorb various PPCPs contamination . Another strategy to control PPCPs contamination is membrane filtration .Use of membrane filtration such as nano filtration are alternatives to remove PPCPs from the sewage or waste water but their pore size is relatively smaller than the PPCPs hence the removal efficiency is poor . Another method to control PPCPs contamination is Advanced oxidation processes (AOPs) such as UV photocatalysis , ozonation and Fenton reaction . Advanced oxidation processes (AOPs) may change the functional group and polarity of the targeted PPCPs . Compounds such as indomethacin , caffeine and sulfamethoxazole were removed using this technique [1].

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2.1.2. Occurrence of organic endocrine disrupting membranes

Endocrine disrupting membranes are present in environment such Natural and synthetic hormone Alkyl phenol, Polycyclic aromatic hydrocarbons , Perfluorinated compounds which are harmful for animals , human beings as well as aquatic life [13].

2.1.3 Occurrence of heavy metals in the environment

Heavy metals such Lead (Pb), Cadmium (Cd), Mercury (Hg), Arsenic (As) are present in different forms in the environment which adversely affects the health of humans , animals as well as disturbs the aquatic life . These heavy metals are present in food cycle, water bodies thus , admistered in the human body and affects the health of humans depending on the duration of exposure and amount of dose [18].

2.1.4 Occurrence of cadmium and health affects associated with cadmium

Cadmium is the seventh most toxic heavy metal as per ATSDR ranking [19] .Cadmium (Cd) is a heavy metal which is naturally found in ores. Cadmium is used as stabilizer in different products like color pigments, several alloys and in Polyvinyl chloride (PVC) related products . Another source of Cadmium exposure is fertilizers (Phosphate).

Number of health effects are associated with cadmium such as Kidney damage, risk of cancer, neurotoxic effects, respiratory problems, bone demineralization, effect on reproduction, Diabetes risk [20].

2.2.QUANTIFICATION METHODS FOR ANALYSIS OF METALS IN AQUOEUS SOLUTION

Inductively coupled plasma optical emission spectroscopy (ICP-OES):

ICP-OES is the most widely used technique for heavy metal analysis from waste water and other sources. This is used for the estimation of metal content present in soil samples as well as in waste water. It is one of the important tools used in analysis of pollution caused by metals. It can be used to determine multiple samples simultaneously for the estimation of heavy metals. It can also be used to determine metals available in nanograms. It can even determine trace metals ions even in limited amount of sample. This technique was investigated by green field and coworkers in 1963.

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2.3.PRODUCTION OF BIOCHAR AND REMOVAL OF MICROPOLLUTANTS WITH BIOCHAR

Heavy metals adversely impacts the health of humans, various activities such as smelting, pesticide and fertilizer applications, mining. Manufacturing discharge have increased the level of heavy metals containing waste water in the aquatic system. Among various techniques used for, bisorption is one of the most common technique as these bioadsorbents are cost effective, easily available in huge amount . Most popular bioadsorbent is biochar , which is a carbon rich , porous material which is produced by pyrolysis of biomass at different temperature conditions <900°C. The production of biochar is easy and it is one of the cost effective technology with number of applications. Biochar is an adsorbent which is renewable in nature and has low cost made by using readily available materials which makes it affordable for communities having low income [21].

Biochar is a carbon rich solid material which is formed by pyrolysis of biomass is low cost method to remove contaminants present in the water. Biochar and its derivatives has the capacity to adsorb various contaminants present in water such as synthetic organics, heavy metals, pathogenic organism . Biochar is formed due to pyrolysis of biomass under absence of oxygen or low oxygen. The properties of biochar such as high cation exchange capacity, high specific surface area and porosity varies because of feed stock and pyrolysis conditions. For production of biochar various bio material such as animal waste, sludge, municipal solid waste and crop residues can be used. Biochar and activated derivative of biochar are capable enough to remove inorganic contaminants, synthetic organics, heavy metals. In addition to this, biochar can also remove anionic contaminants efficiently. In addition to treatment of water with biochar, it also has various other applications such as it is used to increase the soil fertility and crop productivity [22].

2.4. REMOVAL OF MICRPOLLUTANTS WITH EICCHORNIA CRASSIPES (WATER HYACINTH)

Water is used for number of purposes such as drinking, domestic uses, agriculture sectors, industrial sectors .Water contamination level is increasing day by day as effulents from these sectors are directly or indirectly discharged into the water bodies. Eichhornia crassipes also known as water

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hyacinth has drawn attention for removal of contaminants such as toxic metals ions or heavy metals. The material obtained from plant such as biochar, dried root , plant ash , activated

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carbon can be used as adsorbent for removal of contaminants [23].

From past few years huge amount of heavy metals, organic and inorganic compounds present in the waste water which adversely effects the life of animal as well as aquatic life . These hazardous compounds and metals can be removed by the use of water hyacinth. Water hyacinth is a free floating plant and can remove heavy metals such as Cu, Zn , Ni, Pb, Cd present in the waste water . Plants can also remove inorganic and organic compounds present in the waste water. The characteristics of water hyacinth such as high rate of growth, low cost of operation, adsorption efficiency, eco friendly presents that this plant is effective method for waste water treatment . Root of plant plays an important role in uptake of heavy metals. Number of application of water hyacinth is there such as waste water treatment ,removal of organic compounds , removal of inorganic compounds [24] , removal of Heavy metals [11] , production of bioenergy [12] , production of briquette, production of biogas [13], production of animal and fish feed , production of fertilizer [15].Water hyacinth is very effective in removing heavy metals [24]

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3. AIMS AND OBJECTIVE OF THE STUDY

Heavy metals are harmful for environment as well as human beings and are main contaminants of wastewater. Therefore, it is necessary to remove heavy metal using adsorption technique. Biochar formed at different temperatures (400°C, 500°C and 600°C) and Eichhornia crassipes (Water hyacinth) are used as adsorbent for removal of heavy metals.

The following were the objectives of this study:

- Collection and processing of sewage sludge sample from Phagwara sludge drain passing through Lovely Professional University.
- Production of biochar from sewage sludge at different elevated temperatures (400°C, 500°C and 600°C) in muffle furnace
- Preparation of cadmium containing solutions.
- Removal of Cadmium by Biochar prepared by pyrolysis of sewage sludge in and Eichhornia crassipes(Water hyacinth) roots
- Analysis of Cadmium by ICP-OES method.
- Comparison of Cadmium before and after adsorption.

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4. MATERIALS AND METHOD

4.1 MATERIALS USED

4.1.1 Tools

Auger, Bucket

4.1.2 Glass wares

Beakers, Flasks, Crucibles, Falcon tubes, Spatula, Air tight Plastic bags, Whatman filter paper, graduated falcon tubes (50ml)

4.1.3 Chemicals

Cadmium chloride (Monohydrate)

4.1.4 Equipment's and instruments

Weighing balance, Shaker incubator, Muffle furnace, Tripod stand, Mortar and Pestle, Desiccator, Sieve , Water bath, ICP-OES.

4.2 METHOD

4.2.1 PREPARATION OF BIOCHAR FROM SEWAGE SLUDGE

Sewage was collected from the Phagwara sludge drain passing through Lovely Professional University with the help of Auger and collected in bucket.

Collected sewage sludge was then air dried at room temperature and further grinded with the help of mortar and pestle .

Sieving of Grinded dried sewage was done with the help of sieve.

For the formation of biochar at different elevated temperatues , pyrolysis of powdered sewage sludge was done in muffle furnace.

After pyrolysis of sewage sludge which is decomposition of organic matter at high temperature in the presence of low oxygen or oxygen deficient atmosphere, Biochar was taken out of the muffle funace , cooled down and stored in air tight bags for further use.

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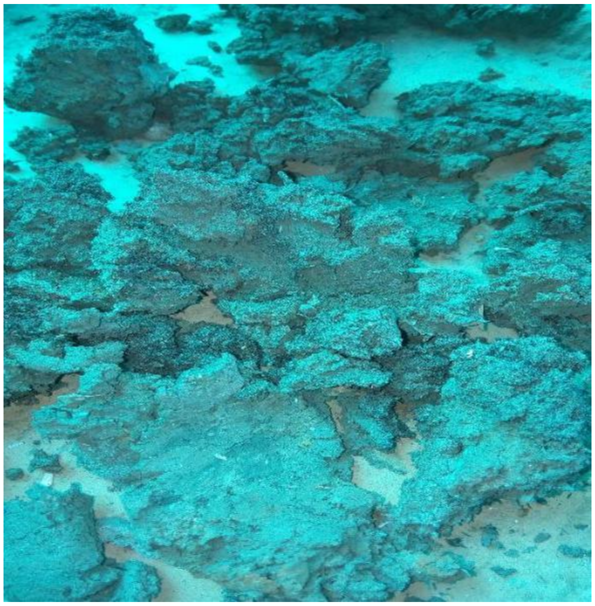

Fig:1 Air drying of sewage sludge collected from phagwara drain passing Lovely Professional University.

Fig 2: Grinding of dried sewage sludge collected from phagwara drain passing Lovely Professional University.

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Fig:3 Sieving of dried sample after grinding

4.2.2 PROCESSING OF Eicchornia crassipes (Water hyacinth) PLANT

Eichhornia crassipes (Water hyacinth) plant was collected .

Roots of water hyacinth pant was excised out and washed with tap water.

Roots of water hyacinth plant was dried at room temperature.

After drying, plant roots was grinded with the help of mortar and pestle and sieving of powder obtained from grinding of roots was done by sieve.

Powdered water hyacinth roots was stored in air tight bags for further use.

Fig :4 Air drying of Eichhornia crassipes's roots (water hyacinth)

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Fig 5: Grinding of water hyacinth's roots in mortar and pestle

Fig 6:Sieving of water hyacinth's roots

4.2.3 Cd CONTAINING SAMPLE PREPARATION OF KNOWN CONCENTRATIONS

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A stock solution of 1000ppm concentration of cadmium chloride was made by adding 0.12g of cadmium chloride monohydrate ($CdCl_2H_2O$) in 70ml of distilled water. Working solution

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of different concentrations (10ppm,50ppm and 100ppm) was made from stock solution. 100ppm solution was made by adding 5ml of stock solution in 45ml distilled water, 50ppm solution was made by adding 2.5ml of of stock solution in 47.5ml distilled water and 10ppm solution was made by adding 0.5ml stock solution in 49.5ml of distilled water.

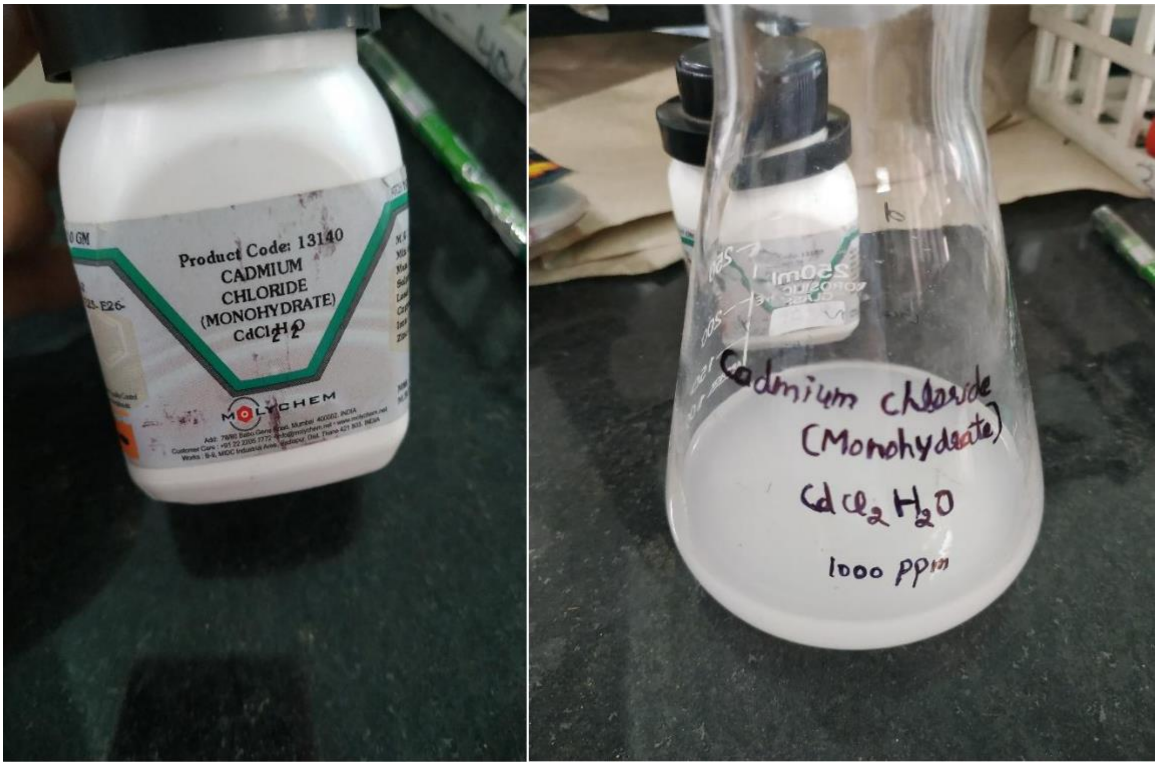

Fig 7: Stock solution of Cadmium chloride

(Monohydrate) 4.2.3 ADSORPTION PROCESS BATCH PROCESS

In Batch process, sorbents such as biochar prepared from sewage sludge and Eichhornia crassipes (Water hyacinth)'s roots powder was added to the conical flask having Cd containing solution (Cadmium chloride monohydrate solution) of known concentrations and then placed in shaker incubator at room temperature and 250rpm. After this , the solution was taken out of the shaker and filtered using whattman filter paper . Filtrate was then separated out in falcon tubes (50ml) for ICP-OES (Inductively coupled plasma-object emission spectroscopy)

Time: vary (30 min ,120min,240min)

Constant : volume, concentration, sorbent, pH,température

Concentration: vary (10ppm,50ppm,100ppm)

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Constant: Time, pH, sorbent, volume, temperature, time, sorbent.

4.2.4 FILTRATION PROCESS

After the batch process, filtration of the solution containing Cd of known concentration and sorbents was filtered using whatman filter paper . Filtrate was then separated out in falcon tubes (50ml) for ICP-OES(Inductively coupled plamsa-object emission spectroscopy) for determining the concentration of Cd present in the filtrate .

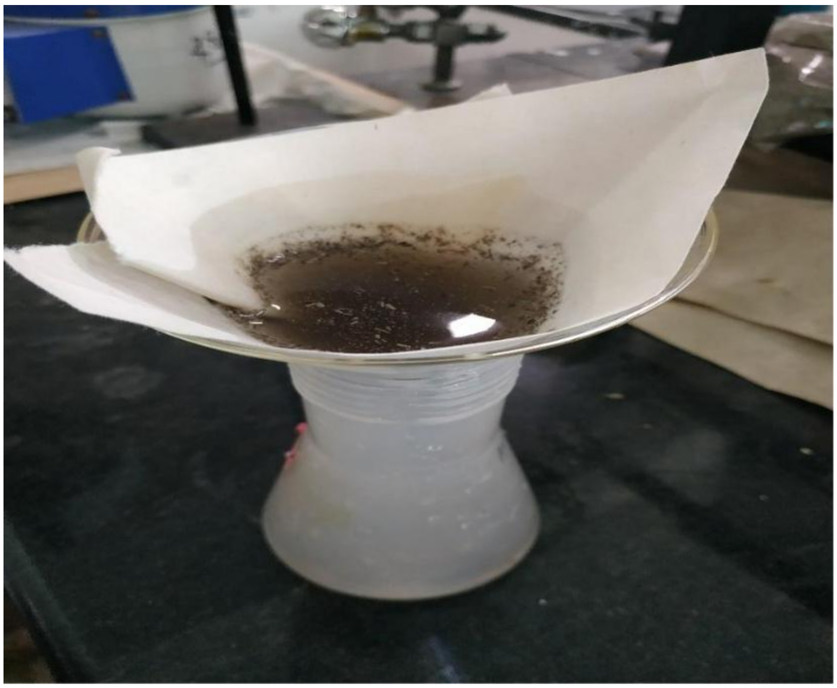

Fig 8: Filtration of solution containing Adsorbent and cd solution after batch process

4.2.6 SAMPLE PREPARATION FOR ICP-OES (INDUCTIVELY COUPLED PLASMA-ATOMIC EMISSION SPECTROSCOPY)

Acid digestion of samples was done for Cd analysis by ICP-OES method. Samples was treated with Nitric acid (HNO3). Nitric acid is the best choice of acid matrix for ICP analysis typically between 1% and 3% w/v. Sample was heated with acid and was reduced in volume.

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4.2.5 ANALYSIS OF SAMPLE CONTAINING Cd AFTER ADSORPTION ROCESS

ICP-OES (INDUCTIVELY COUPLED PLASMA- ATOMIC EMISSION SPECTROSCOPY)

Inductively coupled plasma atomic emission spectroscopy, also referred as inductively coupled plasma optical emission spectrometry, is an analytical technique used for the detection of chemical elements. ICP-OES is the most widely used technique for heavy metal detection in waste water and other sources . This is used for the estimation of metal content present in soil samples as well as in waste water.

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5. RESULT AND DISCUSSION

5.1 BIOCHAR PREPARATION

Biochar was prepared by pyrolysis of sewage sludge collected from Phagwara drain passing through Lovely Professional University. Firstly, the air drying of wet sewage sludge collected from drain was done in order to remove moisture content present in the sludge. Dried sewage sludge obtained was grinded in mortar and pestle in order to get powdered form. Sieving of of dried sewage sludge after grinding was done to get uniform particle size. Biochar was prepared from sewage sludge at different elevated temperatues (400°C, 500°C and 600°C) in muffle furnace

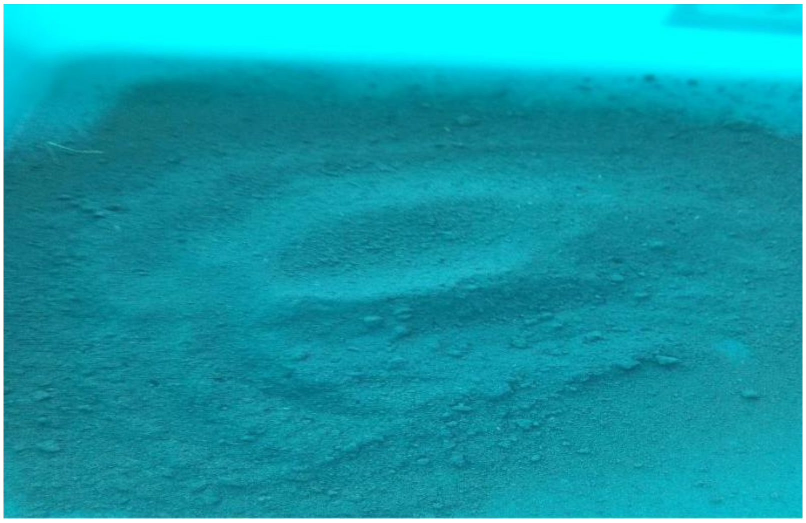

Fig 9: Dried sewage sludge after grinding in mortar and pestle

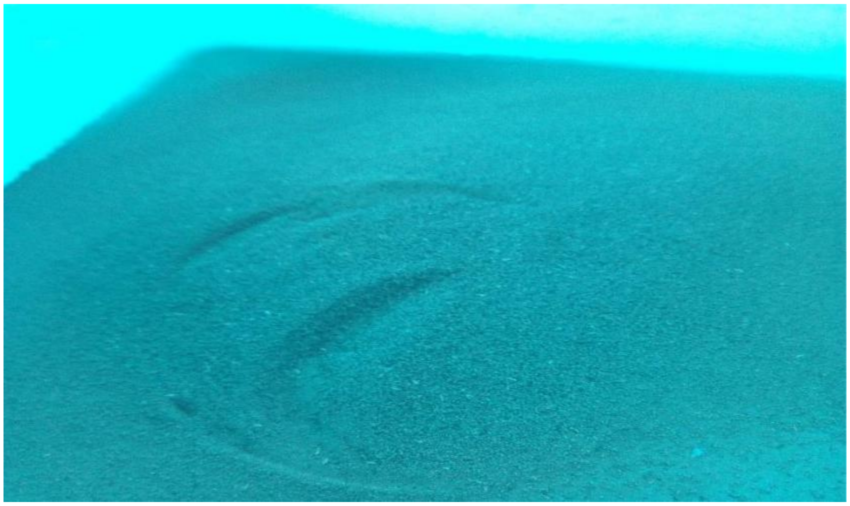

Fig 10: Dried sewage sludge after sieving

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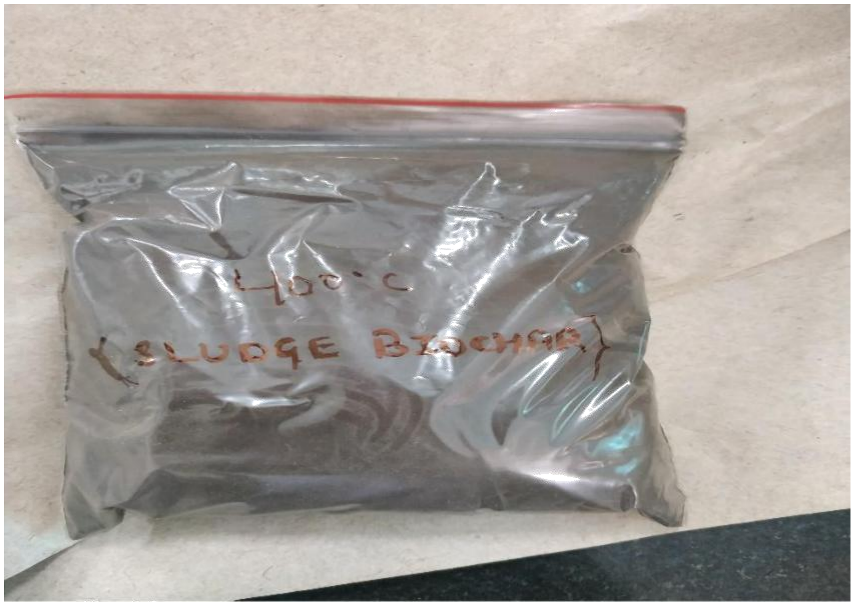

Fig 11: Sludge biochar after pyrolysis at 400°C in muffle furnace

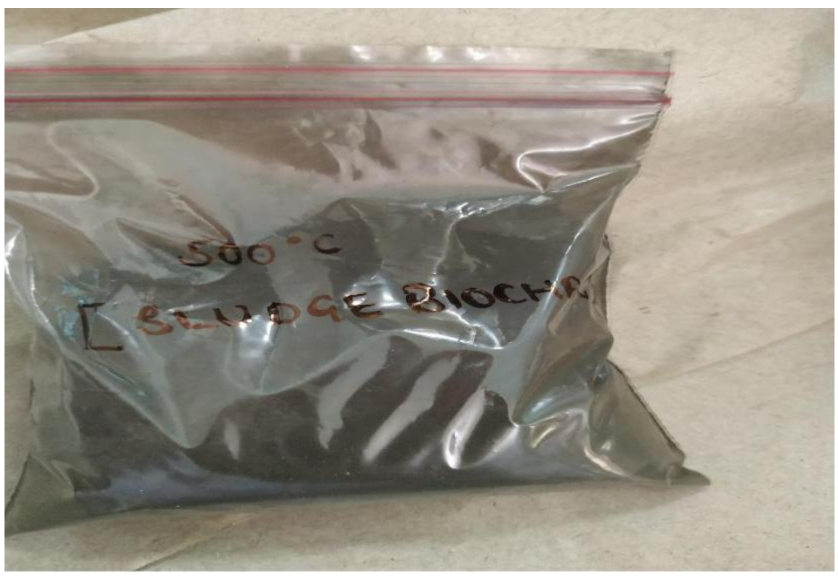

Fig 12 : Sludge biochar after pyrolysis at 500°C in muffle furnace

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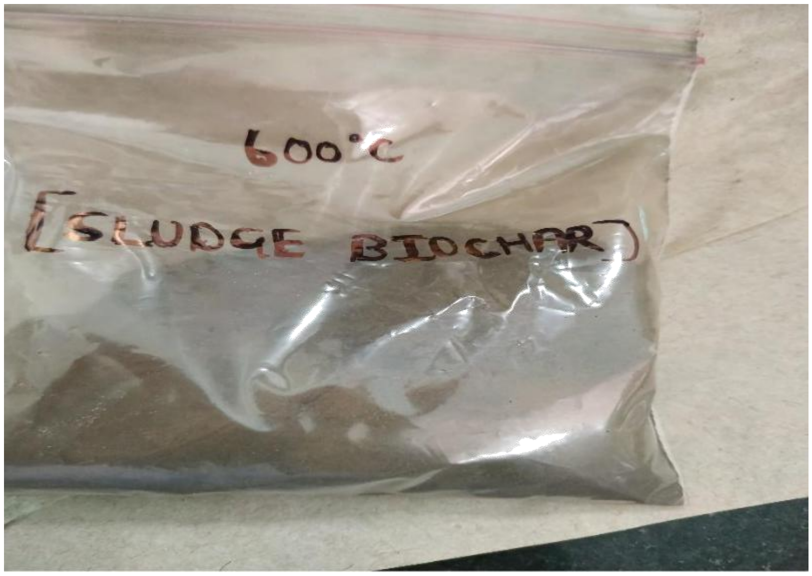

Fig 13: Sludge biochar after pyrolysis at 600°C in muffle furnace

5.2 PROCESSING OF Eicchornia crassipes (Water hyacinth) PLANT

Collected water hyacinth plant's roots after washing with tap water was air dried at room temperature in order to remove moisture content present in water hyacinth's roots. Grinding and sieving of dried roots was done to get powdered form and to get uniform particle size.

Fig 14: Powdered form of Eichhornia crassipes's roots(Water hyacinth)

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5.3 PREPARATION OF Cd CONTAINING SOLUTION OF CADMIUM CHLORIDE (MONOHYDRATE)

Stock solution of cadmium chloride (Monohydrate) was prepared of 1000ppm concentration. Working solutions of different concentration such as 100ppm, 50ppm and 10ppm were formed from stock solution.

5.4 ANALYSIS BY ICP-OES METHOD

After batch process, filtrate was separated out by filtration process in falcon tubes for Cd analysis by ICP-OES method.

Adsorption Capacity: (C0-Ct)/C0 ×100

Where C0 =Initial concentration

Ct= Final concentration

5.4.1 ADSORPTION CAPACITY AT DIFFERENT TIME INTERVALS

SORBENT USED : BIOCHAR PREPARED FROM SEWAGE SLUDGE

Table 2: Adsorption capacity by using biochar formed at different temperature in muffle furnace

Sample Id	Biochar temp	Initial concentration(mg/L)	Final concentration(mg/L)	Adsorption capacity(%)
1	400°C	100	0.039	99.72
2	500°C	100	0.216	99.78
3	600°C	100	0.278	99.96

The adsorption of cadmium (Cd) by biochar prepared from sewage sludge by pyrolysis at different temperature (400°C, 500°C400°C) in the muffle furnace is represented in table number 2. The initial concentration of Cd in sample was 100mg/L. After adsorption process by biochar, concentration of Cd in sample was analyzed by ICP-OES method. Cd concentration after adsorption by biochar formed at 400°C was 0.039mg/l with 99.72% adsorption capacity or percentage removal which is calculated by the above mentioned equation. Cd concentration after adsorption by biochar formed at 500°C was 0.216mg/l with 99.78% adsorption capacity or percentage removal. Cd concentration after adsorption by biochar formed at 600°C was 0.278 with 99.96% adsorption capacity or percentage removal.

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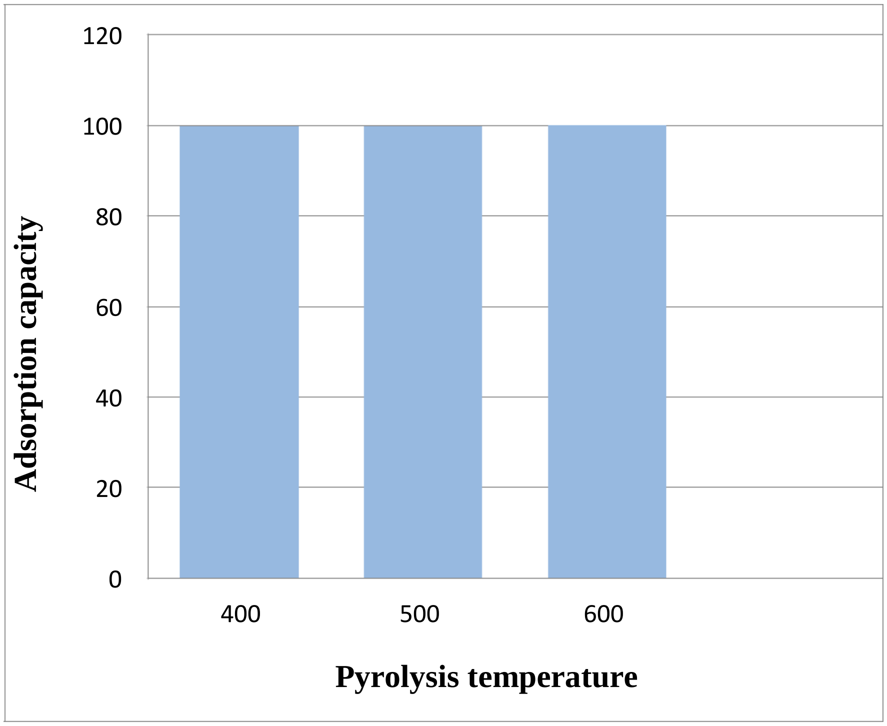
EFFECT OF PYROLYSIS TEMPERATURE ON ADSORPTION BY SLUDGE BIOCHAR



Graph 1: Effect of pyrolysis temperature on adsorption capacity

Effect of pyrolysis temperature on adsorption capacity is respresented in graph 1. According to this, the adsorption capacity increases with increase in pyrolysis temperature as pyrolysis temperature plays an important role in defining the characterisics of biochar formed . According to this adsorption capacity of biochar formed at 400°C was 99.72% , at 500°C was 99.78% and at 600°C was 99.96% which shows that as the temperature of pyrolysis increases , adsorption capacity increases.

According to this adsorption capacity is directly proportional to the pyrolysis temperature.

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As adsorption capacity of sludge biochar formed at 600°C (99.96%) is maximum as compare to 400°C(99.72%) and 500°C(99.78%), it was used as sorbent in batch process for further experiments for removal of Cd from water .

SORBENT USED: BIOCHAR FORMED AT 600°C IN MUFFLE FURNACE

Table 3: Adsoprtion capacity at different time intervals

Sample Id	**Time intervals(mins)**	**Initial Concentration(mg/L)**	**Final concentration(mg/L)**	**Adsorption capacity(%)**
1	30	100	0.039	99.96
2	120	100	0.222	99.77
3	240	100	0.175	99.82

Adsorption of cadmium (Cd) by sludge biochar formed by pyrolysis at 600°C in muffle furnace as a function of time is represented in table 3. According to this table , the initial concentration of Cd present in sample was 100mg/L with varying time (30 mins,120mins and 240 mins). After the adsorption by sludge biochar , the concertation of Cd analysed by ICP-OES method were 0.039mg/l(30mins) with adsorption capacity 99.96% , 0.222mg/l(120mins) and 0.175 mg/l(240mins) with adsorption capacity 99.82%.

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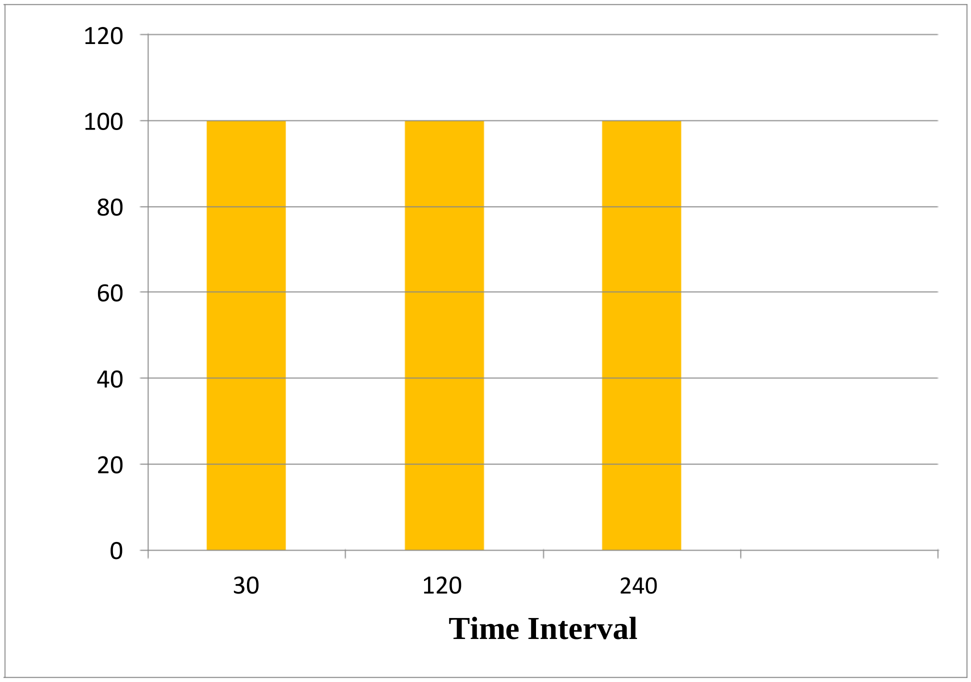
EFFECT OF TIME INTERVAL ON ADSORPTION CAPACITY



Graph 2: Effect of time interval on adsorption capacity of biochar

Effect of time on adsorption capacity is represented in graph 2 where x axis represents time interval and y axis represents adsorption capacity. According to this , the adsorption capacity of biochar is maximum at 30 mins(99.96%) then decreases at 120mins(99.77%) .After decrease in adsorption capacity at 120mins it increased at 240mins(99.82%).

According to this data, the adsorption capacity of biochar is maximum at 30mins contact time and minimum at 240 mins which means that even the contact time between sorbent used and Cd is less it can remove Cd efficiently.

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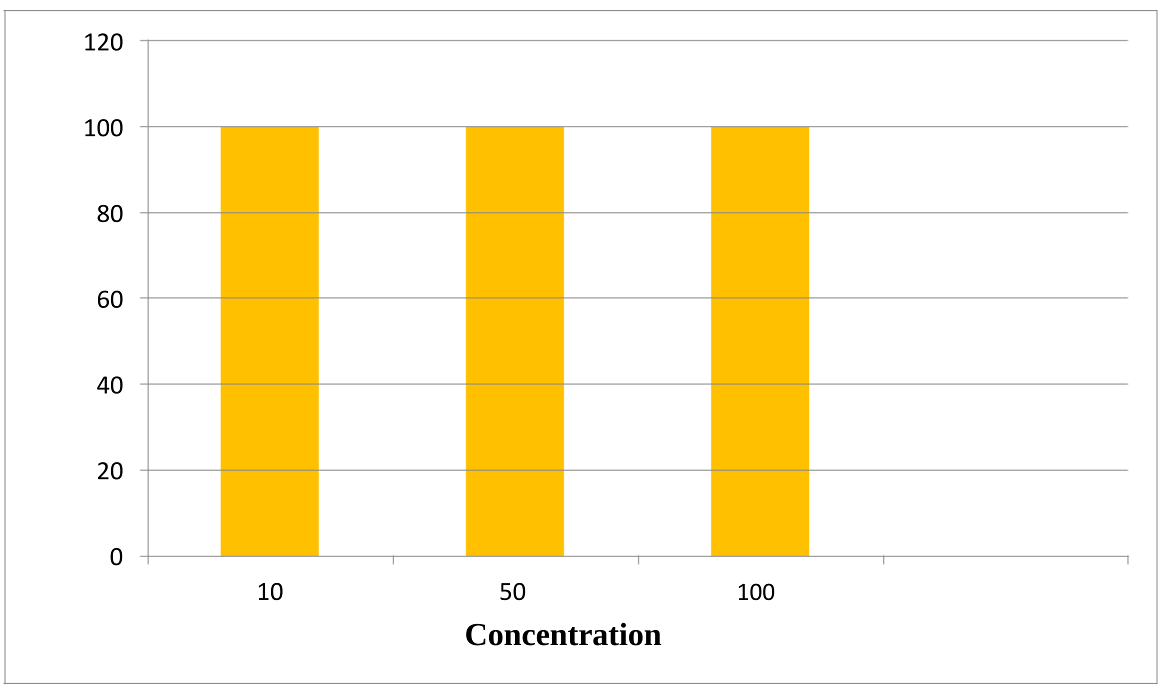
Table 4: Adsorption capacity at different concentrations

Sample Id	Concentration (ppm)	Initial Concentration(mg/L)	Final concentration(mg/L)	Adsorption capacity(%)
1	10	10	0.042	99.58
2	50	50	0.031	99.93
3	100	100	0.008	99.99

Adsorption capacity of Cd with sludge biochar formed at pyrolysis temperature 600°C with varying concentration (10ppm,50ppm and 100ppm) is represented in table 4. After adsorption with biochar final concentration of Cd was 0.042mg/l(initial concentration-10ppm) with adsorption capacity 99.58% , 0.031mg/l(initial concentration-50ppm) with adsorption capacity 99.93% and 0.008mg/l (initial concentration-100ppm) with adsorption capacity 99.99%.

EFFECT OF CONCENTRATION ON ADSORPTION CAPACITY



Graph 3: Effect of concentration on adsorption capacity of biochar

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Effect of concentration on adsorption capacity is represented in graph 3 where x-axis represents concentration of Cd(10ppm,50ppm and 100ppm) and y axis represents adsorption capacity. According to this , Adsorption capacity of biochar increased with increase in concentration. At 10ppm (99.58%) adsorption capacity of biochar was least and at 100ppm(99.99%) adsorption capacity was maximum . At 50ppm adsorption capacity of biochar was 99.92%.

SORBENT USED:WATER HYACINTH'S ROOTS

Eicchornia crassipes (Water hyacinth)'s roots was used as sorbent for adsorption process/batch process.

Table 5: Adsorption capacity at different time intervals

Sample Id	**Time intervals(mins)**	**Initial Concentration(mg/L)**	**Final concentration(mg/L)**	**Adsorption capacity(%)**
1	30	100	0.731	99.26
2	120	100	0.408	99.59
3	240	100	0.262	99.73

Adsorption capacity of Cd by using water hyacinth's roots as sorbent with varying time interval (30mins, 120 mins and 240 mins) is represented in table 5. According to this table, the final concentration of Cd after batch process was 0.731mg/l (30 mins) with adsorption capacity 99.26% , 0.408mg/l(120 mins) with adsorption capacity 99.59% and 0.262mg/l(240mins) with adsorption capacity 99.73%.

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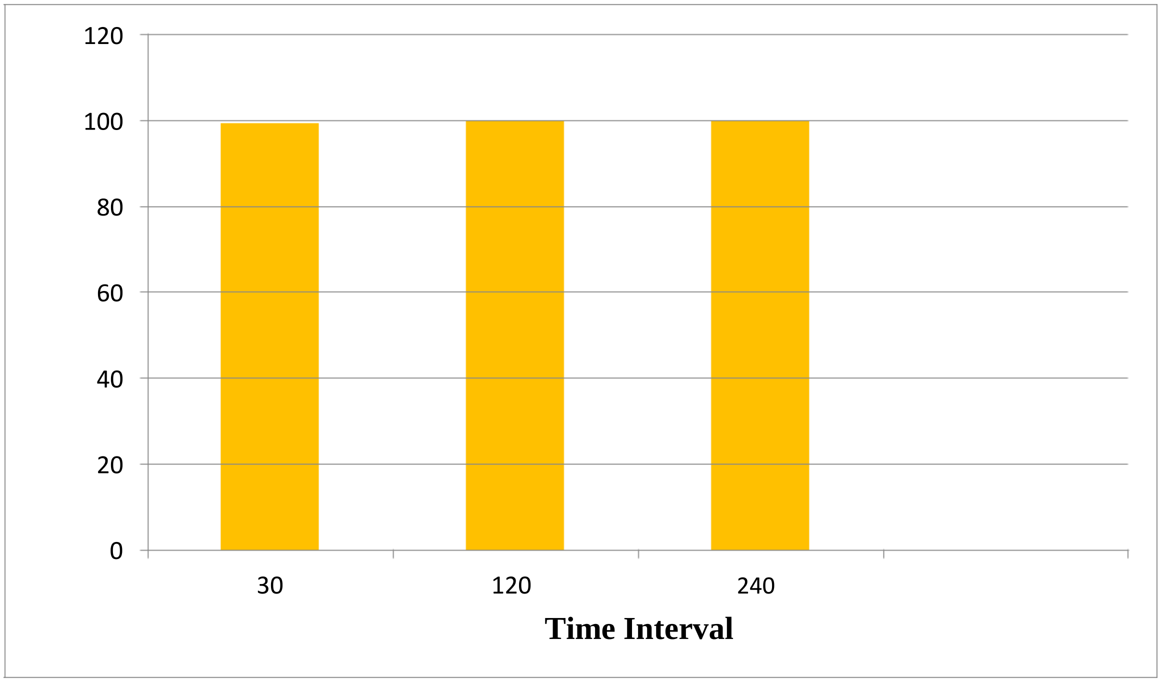
EFFECT OF TIME INTERVAL ON ADSORPTION CAPACITY



Graph4 : Effect of time interval on adsorption capacity of water hyacinth's roots

Effect of time interval on adsorption capacity of water hyacinth's roots is represented in graph 4 where x-axis represents time interval and y –axis represents adsorption capacity. According to this graph ,the adsorption capacity of water haycinth's roots increased with increase in contact time .

At 30mins adsorption capacity of water hyacinth's roots was 99.26% which increased as contact time increased. At 120 mins adsorption capacity of water hyacinth's roots was 99.59% and at 240mins adsorption capacity was 99.73%.

Adsorption capacity of water hyacinth's roots was minimum at 30 mins and maximum at 240mins.

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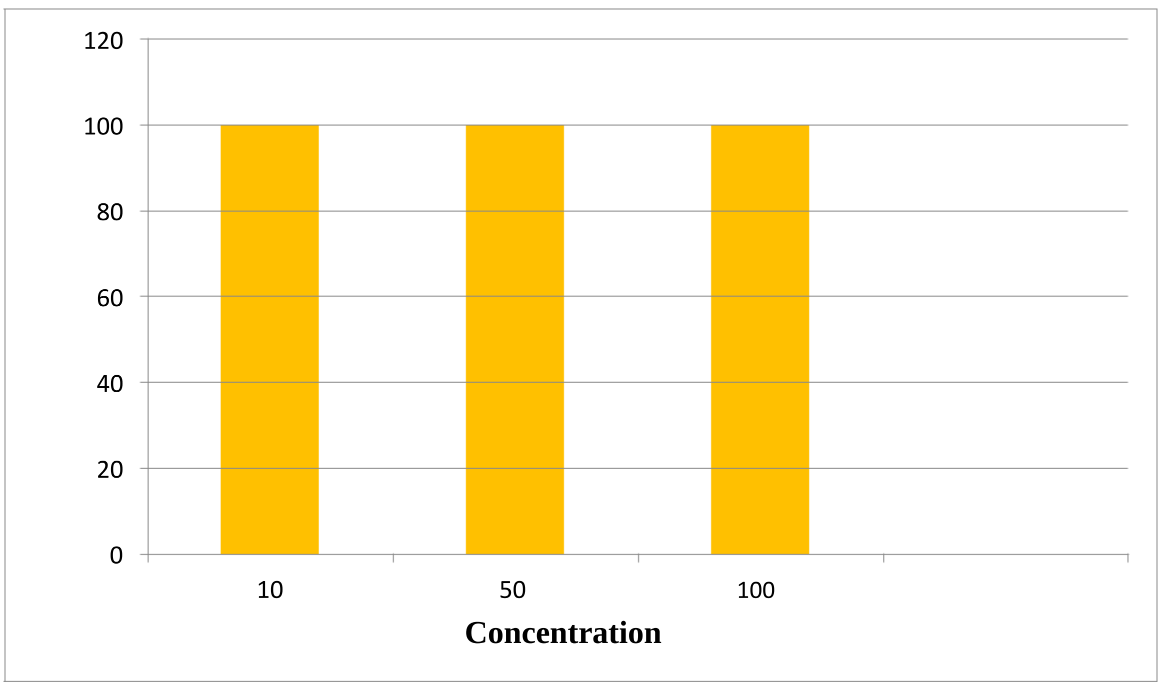
Table 6: Adsorption capacity at different concentrations

Sample Id	Concentration (ppm)	Initial Concentration(mg/L)	Final concentration(mg/L)	Adsorption capacity(%)
1	10	10	0.086	99.91
2	50	50	0.037	99.92
3	100	100	0.016	99.98

Adsorption capacity of Cd using Water hyacinth's roots as sorbent with varying concentration (10ppm ,50ppm and 100ppm) is represented in table 6. According to this table, final concentration of Cd was 0.086mg/l(10ppm) with adsorption capacity 99.91% , 0.037mg/l(50ppm) with adsorption capacity 99.92% and 0.016mg/l(100ppm) with adsorption capacity 99.98%.

EFFECT OF CONCENTRATION ON ADSORPTION CAPACITY



Graph 5: Effect of concentration on adsorption capacity of water hyacinth's roots

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Effect of concentration on adsorption capacity of water hyacinths' roots is represented in graph 5 where x-axis represents concentration of Cd and y-axis represents adsorption capacity. According to this graph, Adsorption capacity of water hyacinth's roots was increased with increase in concentration.

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6. CONCLUSION

Biochar was formed from sewage sludge collected from phagwara drain passing through Lovely professional university by pyrolysis at different temperature in muffle furnace (400°C, 500°C and 600°C). Pyrolysis temperature plays an important role in defining the characteristics of biochar which is basically carbon rich material. The properties of biochar such as high cation exchange capacity, high specific surface area and porosity varies because of feed stock and pyrolysis conditions. Adsorption capacity of biochar formed at 600°C (99.96%) is more as compare to 400°C (99.72%) and 500°C (99.78%) .Thus, Biochar formed at higher temperature removes more Cd from the water as compare to lower temperature.

As biochar formed at 600°C removes Cd more efficiently as compare to 400°C and 500°C it was used for further experiments with varying time intervals (30mins,120mins and 240mins) and varying concentration (10ppm,50ppm and 100ppm). Adsorption capacity of biochar increased with increasing contact time and concentration which means biochar removes more Cd as time of contact increases and even the concentration of Cd is high ,biochar can remove Cd from water efficiently.

Eicchornia crassipes (Water hyacinth)'s roots can also be used as sorbent for removal of Cd from water sample. The material obtained from plant such as biochar, dried root , plant ash , activated carbon can be used as adsorbent for removal of contaminants. Adsorption capacity of water hyacinth's roots was observed with varying time interval and concentration. Adsorption capacity of water hyacinth's roots increased with increasing time interval and concentration. Water hyacinth's roots can considered as one of the effective and low cost method for removal of Cd from water.

Among all other techniques used for removal of heavy metal (Cd) from water or waste water such as Photooxidation, use of Powdered activated carbon (PAC) or Granulated activated carbon(GAC),Advanced oxidation processes (AOPs) ,use of Biochar prepared from sewage sludge and water hyacinth's roots are efficient method for removal of Cd. Advantage of biochar over other techniques is that it is low cost method for removal of cd, easy to prepare and handle, can remove heavy metal efficiently (upto 99% approximately). Other than Cd biochar can also remove other heavy metals such as lead , arsenic, chromium, nickel , oraginc and inorganic dyes, pathogens

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etc. Advantage of Water hyacinth plants over other methods is that it is cost effective method, removes cd efficiently. Water hyacinth plant has advantage over biochar. Plant parts can be directly used for removal of heavy metals or contaminants present in the water.

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