Treatment of Water Using Natural Fibres

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Abstract The environment's top priority is wastewater treatment. Wastewater is treated using a variety of techniques. Membrane separation, chemical precipitation, disinfection, coagulation, ion exchange, adsorption, solvent extraction, electrolysis and chemical oxidation are the techniques we can use to obtain water that is free of contaminants [1]. In addition to the prices and hard currency, there are other factors that affect how much it will cost to receive the desired level of therapy. Numerous chemicals are also linked to issues with human health and the environment. If they are readily available locally, natural materials can greatly lower the cost of treatment while minimising or avoiding the issues. Utilising natural materials lessens the demand for new resources for their processing. Pine needles, pine cones, straw, reed, *M. oleifera*, *Strychnos potatorum* and Moringa seeds [2] are examples of natural fibres that can be utilised for the treatment. Utilising natural resources will contribute to lessening chemical usage as well as sustainable growth.

Keywords Water treatment · Natural fibre · Sustainability

1 Introduction

Water is the second most important thing to support life on the planet. Around 1.3 billion people are still deprived of safe drinking water. Increasing population and unplanned urbanisation have sharply led us to the pollution and poor human health. Water coming from rivers, ponds and lakes and even water from groundwater requires treatment before human consumption. Various metals and toxic substances are present in water which is unfit for drinking. Safe drinking water is the human right

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but the metals which are found in drinking water are becoming the major environmental problem. The conventional method of treatment depends on the type of pollution and the extent of pollution. These treatments should be economically friendly. Conventional methods of purification require chemicals which is not meeting the environmental standards. In the disinfection process of water treatment where chlorine is used, the presence of free chlorine found to react with natural organic matter (NOM). This very particular reaction produces Disinfection By-products (DBP) trihalomethanes, haloacetics and other halogens causes cancer and miscarriages. Moreover, usages of chemical will never lead to a sustainable future, so there is huge need of natural materials soon for treatment of water and leading a sustainable life.

Natural raw materials will not only reduce the treatment cost but also save the country's money for importing chemicals. The coal-based activated carbon will soon be exhausted from the earth, so we need an alternative of that. Various natural substances are there which are capable of producing activated carbon by following standard procedures of its preparation. Coconut shells which acidly activated can act as adsorbents for organic matter. Pine cone extract is used as coagulant for removal of turbid water. Activated carbon produced from pine cones is capable of removal of nitrates, copper and zinc. Activated carbon prepared from pine needles are also capable of removal of nickel and cadmium. Pine needles can also be used as check dams in the rivers during floods. *Moringa oleifera*, Cactus Mucilage and Chitosan can be used for the treatment of turbid water. *Moringa oleifera* and *Strychnos potatorum* contain natural polyelectrolytes which can be used as coagulant to clarify turbid water. Natural raw material studied and which can be used for the treatment of wastewater are as follows.

2 Pine Needles

Pine needles are found in abundance in Himalayan region especially in the states of Himachal Pradesh and Uttarakhand. The Botanical name of Pine Needles is Pinus roxburghii Sarg and is commonly known as Chir Pine [1, 3]. Usage of pine needles in treatment of water will reduce forest fire which happens every summer. Trees are mostly composed of cellulose which burns readily, Pine trees have elongated leaves which have large surface area to their mass which allows them to burn easily. Pine trees have flammable resins which allows them to burn even more easily. Since pine needles are often found in Himalayan Region, when they start burning on the hilly areas fire catches naturally and sometimes spectacularly spreads upwards. The needles which usually accumulate over soil cause the pathway slippery and reduce the soil moisture capacity of it [4]. Collection of pine needles for treatment of water will provide employment in these regions. Pine needles have great adsorption capacity for the various chemicals coming from the industries and domestic wastes. Crushed pine needles of various mesh sizes have the capability of absorbing calcium up to 65% [5]. Reduction in calcium can reduce the incidence of kidney stones, a serious

Fig. 1 Check dams of pine needles [5]

health concern among the Himalayan Villages. Check Dams of Pine Needles across polluted stream during low flow, high flow and during storms (Fig. 1).

The check dams will reduce organic matter which will subsequently decrease the microbial loading and biochemical oxygen demand in the downstream. The chemical oxygen demand will also get reduced due to the adsorption of calcium, boron and sodium. The activated carbon prepared from the pine needles can reduce the biochemical oxygen demand, chemical oxygen demand and total dissolved solids. These check dams when placed in seasonal streams conserved soil and moisture by decreasing the speed of runoff [6]. The increased moisture regime around the check dam area helped in preventing occurrence and spread of forest fires [5]. Activated carbon prepared from crushed pine needles is to be used to evaluate its potential to eliminate some toxic metals such as cadmium and nickel. The activated carbon was prepared after washing, drying and crushing the pine needles. The crushed pine needles had gone through the carbonisation process and followed by activation. For the chemical activation, biomass was impregnated with different compounds like KOH, $ZnCl_2$, etc. The activated carbon prepared from the crushed pine needles has great adsorbent capacity used for the treatment and removal of heavy metals from the industrial wastes. The purpose of the study is to find characterisation of activated carbon produced from crushed pine needles to evaluate the removal of Cd and Ni. The choosing of pH to be adopted in the study was based on the metal hydroxide solubility in solution. Cadmium and nickel both become insoluble in water at the pH above 8. Thus, the testing was limited to the pH 8. The array of tests was performed at different pH listing 5, 6, 7 and 8 and concentrations of cadmium were

1 and 5 mg/L. The nickel concentrations were 2 and 6 mg/L. The capacity of a newly prepared activated carbon to adsorb Cd and Ni was tested under various operating conditions. pH of solution proved to have a major impact on the adsorption capacity of the AC. In general, it was observed that an increase in solution pH led to an improvement in the removal capacity of the AC. The initial concentration of heavy metals had a clear effect on the adsorption capacity of the AC for metals. In batch experiments, higher concentrations always resulted in higher removal and higher adsorption capacity. In column testing, high concentrations (40–50 mg/L) overwhelmed the capacity of the AC for removal and resulted in lower adsorption capacities. In fixed columns, Cd was better removed at the lower concentrations (5 mg/L), while Ni removal was almost stable in the lower and middle ranges, and dropped significantly when the initial concentration was at the maximum value of 40 mg/L. For Cd, the highest capacity in column testing reached 17.54 mg/g, and a much higher removal capacity was obtained in batch experiments, reaching 43.47 mg/g. The highest Ni capacity in column testing was 20.85 mg/g, while a much higher removal capacity of 87.03 mg/g was reached in batch experiments [7].

3 Pinecones

Activated carbon prepared from pine cones will reduce its littering in the forest and will help in removal of zinc oxides coming out of the industries. Here, pine cones of Turkey named as Pine Cones Turkish Pines are used for the study. Different contact times like 20, 40, 60, 80, 100, 120, 140, 160 and 180 min were considered with the 3 g of adsorbent dosages at different pHs. 50 mL of wastewater in conical flask was closed and rotated at 250 rpm in rotary shaker. The percentage of zinc removal drastically decreased from 96 to 57% with the increase in the zinc concentration from 5 to 35 mg/L. The best efficiency of zinc removal was at pH 7 with 96% [6].

Powdered form of pine cones can be used to remove copper (II) from the industrial wastes. Pine cones in powdered form cannot be used directly for the usage, so there is a modification required to enhance the properties. Because usage of raw agricultural waste directly has some limitations such as it will increase the chemical oxygen demand, biochemical oxygen demand and total organic carbon. This happens because plant materials releases soluble organic compounds. Dilute NaOH is capable of solubilising a small portion of the soluble organics and lignin present in plant materials. After performing batch study on the biosorption of copper (II) from aqueous solution with several parameters such as pH, dosage of biosorbent and lastly temperature, we can conclude that the optimum pH was 5 and the biosorbent dosage was 8 mg/L for all samples. Increasing temperature will increase the biosorption [8].

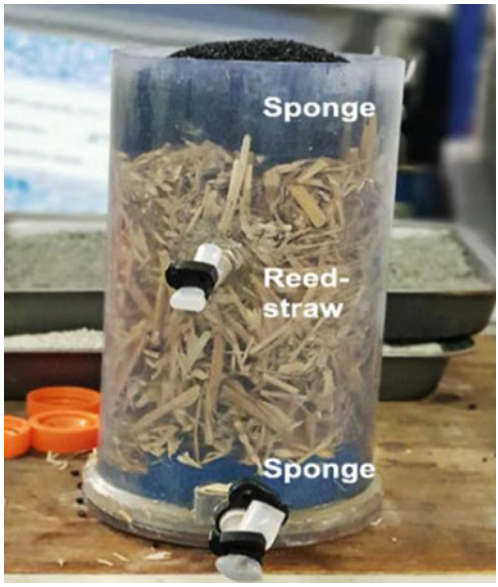

Fig. 2 Straw and reed filtration system [9]

4 Straw and Reed

Presence of iron in potable water is also a critical issue. Removal of iron from water is an expensive process which can be achieved through chemical precipitation and reverse osmosis. Agricultural waste like straw and reed can be used for the removal of iron to some extent. Straw and reed are used in the ratio of 1:1 of mass. A filtration system is established for this purpose (Fig. 2).

An artificial iron solution is produced of 10 mg/L by dissolving suitable amount of iron sulphates in deionised water. This artificial solution was treated with natural filtration system for the different retention times and different pHs of solution. The time ranging was 10–90 min and pH ranges from 4 to 9. After the entire test has been performed, it was calculated that 33.1% of iron was removed from the solution at the pH of 7 and the retention time was 80 min. So, there is positive result through the application of natural filtration which is most importantly sustainable. There is one drawback in this method is that it imparts colour after the filtration which can be removed further with suitable techniques [9].

5 Strychnos Potatorum and Moringa Oleifera

The seeds of Strychnos potatorum and Moringa oleifera contain certain elements which act as polyelectrolytes which can be used to treat turbid water [10]. Natural polyelectrolytes originated from the plants are used for many centuries to treat

water in developing countries. These natural fibres can be used as homemade water filtration system [11]. Strychnos potatorum is often found in central and southern India. Moringa Oleifera is a widely found plant. In some of the villages of Maharashtra and Tamil Nadu, Strychnos potatorum is used to treat turbid water. Women of Sudan uses Moringa Oleifera for the homemade water treatment system. Seeds of Strychnos potatorum were dried and made in powdered form and were sieved through 150 mm sieve and a suspension of 2% was prepared with distilled water. Kernels of Moringa Oleifera were also dried and converted into powdered form and thoroughly pounded in a mortar to produce a pasty powder and 2% of suspension was produced. During the lab tests the direct filtration of raw water with characteristics are 15–25 NTU, heterotrophic bacteria 280–500 CFU/mL and faecal coliforms 280–500 MPN 100/mL was conducted. The seeds of Strychnos potatorum and Moringa oleifera were used as coagulant which subsequently produce an improved quality of water with new characteristics such as 0.3–1.5 NTU, heterotrophic bacteria 5–20 CFU/mL and faecal coliforms 5–10 MPN 100/mL. These natural coagulants certainly do not remove the entire coliform bacteria but reduce a low risk level. Additional boiling and other disinfection processes can be adopted to have safe drinking water [12].

6 Conclusion

Natural fibres are cheap and easily available around the world. Moreover, it will lead to a sustainable world. Pine needles and pine cones are found in abundance around the Himalayan Regions. They will help to treat the waste water as well as industrial wastes. They can be used as adsorbents and activated carbon produced from them has great adsorbent capacity. Straw and reed can be used as filtration system in which content of iron can be reduced. This usage will also help in reducing agricultural wastes. Strychnos potatorum and Moringa oleifera can be used as natural coagulants. Therefore, more study in this field will reduce chemical loading in treatment of water and subsequently leading to a sustainable future.

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