



Water Pollution

Lovepreet Singh
Assistant Professor
Department of Chemistry
Asra Group of Institutions, Punjab, India

Abstract:

Water is essential for life. But now a days, it has been polluted by various sources. Heavy metals are playing an important role. The need of the hour is to generate effective methods for the removal of these metals.

Keywords: Industrial effluents, bio-accumulation, column chromatography.

I. INTRODUCTION

Water is a basic source of life, energy and thus is essential element to all living things on earth. In purest form water is odorless, colorless and tasteless in nature. Level of contaminants has increased due to discharge of industrial effluents in aquatic ecosystems which pollute and contaminate the water streams naturally. However millions of people worldwide are suffering from shortage of fresh and clean drinking water. Water pollution raises a great concern now a days due to rapid industrialization e.g. metal mining operations, fertilizers, agricultural wastes, sewage, domestic wastes, alloy and leather industries, metal galvanizations, paper industries and pesticides which have largely discharged various types of pollutants into environment and cause disorder into ecosystem. Chemicals, paper, petroleum and primarily metal sectors cause about 97% of water contamination. Heavy metal pollution caused by industrial activities and technological development is posing significant threats to the environment and public health because of its toxicity, non-biodegradability, bioaccumulation and persistent tendency through food chain. 'Heavy metals' refers to any elements with atomic weights between 63.5 and 200.6 with specific gravity greater than 5.0. Nickel is one of the non biodegradable, toxic, heavy metal ion present in waste water and ground water. Nickel was first isolated from mineral nicolite by Swedish Chemist Axel Crostedt in 1751 and the name "nickel" was derived from the term "Kupfenickel" which means 'Old Nick's Copper' that the German miners gave to nicolite because of emission of toxic fumes when heated. The permissible limit of nickel in drinking water given by U.S. Environmental Protection Agency (EPA) is 0.015 mg/l. Nickel compounds released by industrial activities into the environment will adsorb onto the sediment and soil particles and become immobile. Nickel is more mobile in acidic soils and often leaches out into the groundwater. Concentration of nickel in industrial waste waters ranges from 3.40 to 900 mg/l.

II. SOURCES OF NICKEL

Nickel is released into the environment through natural and anthropogenic sources (Chen and Lin, 1998). Natural source of nickel to the environment are forest fires, vegetation, volcanic emissions and windblown dust. Anthropogenic sources of nickel to the environment are combustion of coal, diesel oil and fuel oil, the incineration of waste and sludge, use of phosphate fertilizers, stainless steel industry, galvanization,

smelting, dyeing operation, batteries manufacturing, metal finishing, jewellery manufacturing, coinage, catalyst, nickel mining and processing etc. (Nordberg, et al., 2005; Krishnan et al., 2011) and other miscellaneous sources (Von, 1997). Industrial emissions add more than 100 times more nickel than that from natural sources e.g. in effluents of electroplating industries to the tune of 20-200 ppm (Revathi, 2005), effluents of silver refineries, zinc base casting and storage battery industries. The main pollution are from nickel plating industry (Cempel and Nickel, 2006) caused by Ni^{+2} heavy metal ion in water. Nickel is present in small quantities (0.1-0.6 ppm) in plants, animals and in small quantities in sea water. All these industries acquire established waste water regulations to minimize the human and environmental exposure to hazardous heavy metals. Some of other industrial processes that contribute to the presence of nickel are bakery (0.43 mg/l), soft drinks and flavoring (0.22 mg/l), ice cream (0.11 mg/l), textile dyeing (0.25 mg/l), laundry (0.1 mg/l), car wash (0.19 mg/l) and miscellaneous foods (0.11 mg/l) (Rao et al., 2001).

III. DELETERIOUS EFFECT OF NI (II) IONS IN THE ECOSYSTEM AND ENVIRONMENT

Ni (II) is an essential nutrient needed by the body in trace amounts because it takes part in the synthesis of vitamin B12. However increase in the intake of Ni(II) or its compounds can lead to birth defects, embolism, asthma, hard metal related respiratory diseases and chronic bronchitis, etc. (Chen et al., 2008; Chen et al., 2009). Nickel toxicity associated with Ni(II) is mainly due to generation of reactive oxygen species (ROS) with subsequent oxidative deterioration of biological macromolecules. There are two step processes in which nickel can generate free radicals (FR) directly from molecular oxygen to produce superoxide anion and in continued process, produce highly toxic hydroxyl radical. They also inhibit antioxidant enzymes and deplete intracellular glutathione and causes pro-oxidative effects (Das, 2009). Toxicity of nickel causes pulmonary fibrosis and inhibits many enzymatic functions (Liphadzi and Kirkham, 2005) and skin contact with nickel causes a painful, fatal disease called "nickel itch" (Bailey et al., 2005). The higher concentration of nickel causes harmful health effects like headache, dizziness, nausea, dry cough, tightness of the chest, chest pain, cyanosis, vomiting, shortness of breath, nasopharynx, cyanosis, extreme weakness, renal oedema, skin dermatitis, gastrointestinal disorder and rapid respiration (Chen et al., 2009). Sulphide and oxide form of nickel posse's excess risk of lung and nasal cancers (Satpathy,

2002). Due to deleterious effect of nickel WHO (World Health Organization) has prescribed standards for desirable nickel concentration in drinking water, therefore it is necessary to bring the nickel concentration in waste water below the prescribed limit.

IV. ADSORPTION PROCESS FOR THE REMOVAL OF HEAVY METALS FROM WATER AND WASTE WATER

Recently adsorption process has gained great interest as a more promising method because it is more effective and economic process for heavy metal removal. Adsorption is a technique through which some of fluid phase substances are removed by their transmission to the interface between fluid phase and solid (separate) phase and accumulation. Reduction in surface tension occur between the fluid and the solid phase because adsorption of fluid phase substances on the solid surface create required driving force for adsorption process. Adsorption also occurs due to the attractive interaction between a surface and the species being adsorbed at certain level (Monser and Adhoum, 2002). Solid porous material is called adsorbent material or biomass and components of fluid phase that adsorb by solid phase is called adsorbed component or adsorbate. Movement of fluid phase components (adsorbate) and their accumulation on the solid surface will terminate as soon as the concentration of adsorbate at two phases reach an equilibrium condition. Non living biomass or natural biomass are used widely as metal binding agents because they have the capacity to lower the metal ion concentration to Parts Per Billion (ppb) level due to their affinity for cationic metals.

V. FACTORS AFFECTING THE ADSORPTION PROCESS

Adsorption process is mainly influenced by the nature of solution in which the contaminants are dispersed and the nature of adsorbent used. Some parameters should be considered during the adsorption process between adsorbent and adsorbate which are given below (Cheremisinoff and Morresi, 1978).

- **pH of solution:** pH is determination of adsorption in terms of hydrogen ion concentration. The adsorptive capacity of metal cations increase with increasing pH of the sorption system, but not in linear relationship. Sorption not occurs at highly acidic and alkaline conditions because hydrogen ions and hydroxyl ions compete for active sites on adsorbent surface respectively.
- **Degree of ionization of the adsorbate:** More highly ionized molecules are adsorbed to a small degree than neutral molecules. The degree of ionization of a species is affected by the pH.
- **Particle size:** It is the size of the molecule with respect to size of the pores. Larger molecules may be too large to enter small pores. This may reduce adsorption independent of other causes. Smaller particle sizes reduce internal diffusion and mass transfer limitation to the penetration of the adsorbate inside the adsorbent i.e. equilibrium is more easily achieved and nearly full adsorption capacity can be attained.
- **Surface area of adsorbent:** Large surface area provides greater adsorption capacity. Smaller the particle size and contain greater the surface area of the adsorbent more is the adsorption.

- **Temperature:** Adsorption reactions are normally exothermic, so adsorption capacity increases with decrease of temperature. In the range of 15-40⁰C, the maximum equilibrium adsorption capacity for Ni (II) ions by the wood ash was reached at temperature of 25⁰C (Parmar and Thakur, 2013).
- **Effect of adsorbent dose:** The percent removal of heavy metals increases rapidly with increase in concentration of adsorbents (Parmar and Thakur, 2013). But after certain concentration of adsorbent further increase in biomass concentration has no effect on removal percentage because no metal ions left to be adsorbed on the empty active sites after equilibrium point is achieved.
- **Effect of initial concentration of metal ion:** The initial concentration of metal ion provides an important driving force to overcome all mass transfer resistance of metal between the aqueous and solid phases. There is a decrease in resistance for the uptake of solute from solution with increase of metal ion concentration (Parmar and Thakur, 2013).
- **Contact time:** Longer the contact time or retention, more complete adsorption will be achieved. But after the equilibrium has been achieved there is no increase in percent removal of metal ion.
- **Solubility of solute:** Substances slightly soluble in water will be more easily removed from water than substances with high solubility.
- **Effect of agitation rate:** Agitation means proper mixing of adsorbate and adsorbent. The adsorption removal efficiency is increased weakly with increasing agitation rate (Parmar and Thakur, 2013).

VI. VARIOUS LOW COST ADSORBENTS USED FOR THE REMOVAL OF NICKEL.

Generally an adsorbent can be considered as "low cost" if it requires little processing, abundant in nature and if it is a byproduct or waste from industry. Natural material or certain waste from industrial or agricultural operation is one of the resources for low cost adsorbents and are locally and easily available in large quantities; therefore they are inexpensive and have little economic value. A vast variety of raw materials originate from industrial and agricultural activities, results in production of chemical and solid wastes. The chemical wastes arise from the use of pesticides, dyes and fertilizers while the solid wastes include bagasse, sawdust, rice husk, peanut shell, coffee husk etc. and it is a concept of "using waste to treat waste". Various non conventional and less expensive adsorbents which are natural materials or wastes (used either naturally or with some chemical modifications) have been investigated for removal of Ni (II) such as sphagnum peat (Viraraghvan and Drohamraju, 1993), blast furnace slag, apple waste, soybean and cottonseed husk, peanut husk carbon, straw treated saw dust, activated alumina and silica gel. Several types of other adsorbents e.g. clay, activated carbon, zeolite, silica gel and the agricultural adsorbents such as coffee husk, peanut shells, bagasse, rice husk and sawdust are widely used (Argun et al., 2007).

VII. CONCLUSION

Biomass is the cheap and easily available material for the removal of nickel from Industrial effluent. It is going to be one of the best method for the purpose.

VIII. ACKNOWLEDGMENT

I am thankful to Prof. Rajeev Sharma, HOD Chemistry, Multani Mal Modi College, Patiala, Punjab, India for encouraging me to do research in this field.

XI. REFERENCES

[1]. Abas Siti Nur Aeisyah, Mohd Halim Shah Ismail, Md Lias Kamal and Shamsul Izhar (2013). Adsorption process of heavy metals by low cost adsorbents: A review. *World Applied Sciences Journal*, 28 (11): 1518-1530, ISSN 1818-4952.

[2]. Akhtar, S.M., Chali, B. and Azam, T. (2013). Bioremediation of arsenic and lead by plants and microbes from contaminated Soil. *Research in Plant Sciences*. 1(3): 68-73.

[3]. Argun M E., Dursun, S, Ozdemir, C., Karatas, M., 2007. Heavy metal adsorption by modified oak sawdust: thermodynamics and kinetics. *J.Hazardous Mater. B* 141, 77-85.

[4]. ATSDR (2005). Toxicological profile of nickel. Atlanta, GA: Agency for Toxic substances and disease Registry.

[5]. Balat M., (2008). *Energy source Part A*. 30, 620.

[6]. Bolto B, Dixon R, Eldridge S, King and K. Linge (2002). *Water Res.*, 36, 5057.

[7]. Bell J., J J. Buckley C A and Stuckey D C. J. (2000). *Environ. Eng, ASCE* 126, 1026.

[8]. Bahadir, T., Bakan, G., Altas, L., Buykgungar, H. (2007). The investigation of lead removal by biosorption. An application at storage battery industry wastewaters. *Enzyme Microbiology Technology*. 41: 98-102.

[9]. Chen H, Liu S C. Chen C Y, Chen C Y. (2008). *J. Hazard Mater.* 154, 184.

[10]. Chen H, Yang C Y, Chen C Y, Chen C Y, Chen C W. (2009). *J. Hazard Mater.* 163, 1068.

[11]. Chau YK, Kulikovskiy-Cordeiro OTR (1995). Occurrence of nickel in Canadian Environment. *Environ Rev.*, 3: 95-120. Higgins SJ (1995). Nickel 1993. *Coordination Chemistry Reviews*. 146:115-201.

[12]. Chen C. Y. and Lin, T.H., *J. Toxicol. Environ. Health Part A*. (1998), 54,37-47 (Cross Ref).

[13]. Cheremisinoff, P.N. and A.C. Morresi, 1978. *Carbon adsorption Handbook*. An Arbor Science Publishers, Brought Green, pp: 1-57.

[14]. Calace, N., Nardi, E., Petronio, B.M., Pietroletti, M., Tosti, G., 2003. Metal ion removal from water by sorption on paper mill sludge. *Chemosphere* 51 (8), 797-803.

[15]. Carrasco-Martin F., A. Mueden, T. A. Centeno, F. Stoeckli, C. Moreno Castilla, *J. Chem Soc. Faraday Trans.*, 93 (1997) 2211-2215.

[16]. Coogan TP, Latta DM, Snow, ET, Costa M (1989). Toxicity and carcinogenicity of nickel compounds. *Crit. Rev. Toxicol.*, 19(4): 341-384.

[17]. Das Kusal K. (2009). A comprehensive Review on Nickel (II) and Chromium (VI) Toxicities- Possible Antioxidant (*Allium Satium Linn*) Defenses. *Al Ameen J Med Sci* (2009) 2 (2) Special: 43-50, ISSN 0974-1143.-

[18]. Demirbas, E., M. Kobya, S. Oncel, S. Sencan, *Biores. Tech.*, 84 (2002), 291-293.

[19]. Esplugas S, Gimenez J. Contreas S, Pascual E, and Rodriguez M. (2002). *Water Res.*, 36, 1034.

[20]. Eccles, H, 1999. Treatment of metal contaminated wastes: why select a biological process? *Trends in Biotechnology*, 17:462-465.

[21]. Gaballah I., G. J. Kilbertus, *Geochem. Explor.* 62 (1998)241-286.

[22]. Garbarino, J.R., H. Hayes, D.Roth, R. Antweider, T.I. Brinton and H. Tailor, 1995. Contaminants in the Mississippi River, U.S. Geological Survey Circular 1133, Virginia, U.S.A.

[23]. Gupta VK., Jain CK., Ali I., Sharma M., Saini VK. Removal of Cadmium and Nickel from waste water using bagasse fly ash-A suger industry waste" *Water Res.*, Vol. 37, pp 403 44, 2003.

[24]. Hawkes J.S., 1997. Heavy Metals. *Journal of Chemical Education*. 74(11):1374.

[25]. Jarup, L., 2003. Hazards of Heavy Metals Contamination, *British Medical Bulletin*, 68:167-182.

[26]. Jiang Y., Huang C.J., Pang H., Liao B., (2008). Progress in cellulose based Adsorbents. *Chemistry*. 71 (12).

[27]. Joshi, N., Ahluwalia, S.S., Goyal, D., 2003. Removal of heavy metals from aqueous solution by different bio-waste materials. *Research Journal Chemistry & Environment* 7 (4), 26-30).

[28]. Kobya, M., Demirbas, E., Senturk, E., Ince, M., 2005. Adsorption of heavy metal ions from aqueous solution by activated carbon prepared from apricot stone. *Bioresource Technology* 96, 1518-1521.

[29]. Kotov V, Nikitiana E (1996). Norilsk: Russia Wrestles with an old polluter, *Environment*, 38: 6-11.

[30]. Krishnan A K. Sreejalekshmi K G, Baiju R S. (2011). *Bioresource Technol.* 102,10239.

[31]. Liphadzi MS and Kirkham MB (2005). Phytoremediation of soil contaminated with heavy metals, a technology, a technology for rehabilitation of the environments. *South African Journal of Botany.*, 71:24-37.

[32]. Li X, Tang Y, Xuan Z, Liu Y, Luo F, 2007. Study on the preparation of orange peel cellulose adsorbents and biosorption of Cd²⁺ from aqueous solution. *Sep. Puri, Technol.*, vol, 55, pp. 69-75.

[33]. Low, K.S., Lee, C.K., Leo, A.C., 1995. Removal of metals from electroplating waste using banana pith. *Bioresource Technology* 51 (2-3), 227-231.

- [34]. Marin, J., Ayele, J., 2002. Removal of some heavy metal cations from aqueous solutions by spruce sawdust. I. Study of the binding mechanism through batch experiments. *Environment Technology* 23 (10), 1157-1173.).
- [35]. Monser, L., and N. Adhoum, 2002. Modified Activated Carbon for the removal of copper, Zinc, Chromium and Cyanide from waste water. *Separation and Purification Technology*, 26 (2/3):137-146.
- [36]. Namasivayam M D, Kumar K, Selvi R A, Begum T, Vanathi and Yamuna , (2001). *Biomass Bioenerg.* 21, 477.
- [37]. Nordberg, F. , B. A. Fowler , M. Nordberg, L. Friberg, *Handbook of Toxicology of metals*, European Environmental Agency, Copenhagen, 2005; A. H Muhammad, N. Razia, N. Z. Muhammad, A Kalsoom, N. B. Haq, *J. Hazard Mater.*, 145 (2007) 501-505.
- [38]. O'Connell D W, Birkinshaw C, O'Dwyer T F. (2008). *Bioresource Technol.* 99, 6709.
- [39]. Olayinka Kehinde, O. Adetunde Oluwatoyin, T., and Olayinka Aderonke O. (2009). Comparative analysis of the efficiencies of two low cost adsorbents in removal of Cr (VI) and Ni (II) from aqueous solution. *African Journal of Environmental Science and Technology*. Vol. 3 (11), pp. 360-369. ISSN 1991-637X©2009 Academic Journals.
- [40]. Pala and ToKat E. (2002). *Water Res.* 36, 2920.
- [41]. Parmar M and Thakur LS (2013). Adsorption of heavy metals [Cu (II), Ni (II), and Zn (II)] from synthetic waste water by tea waste adsorbent. *IJCPS*, 2(6), 6-19.
- [42]. Perez-Marin, A.B., Ballester, A., Gonzalez, F., Blazquez, M.I., Munoz, J.A., Saez, Meseguer Zapata, V., (2008). Study of cadmium, zinc and lead biosorption by orange wastes using the subsequent addition method. *Bioresource Technology*. 99: 8101-8106.
- [43]. Patterson J., R. Passino, *Metal Speciation, Separation and recovery* , Lewis Publishers. Inc., Chelsea, (1987).
- [44]. Pino GH, Mesquita L M S, Torem M L & Pinto G A S, *Biosorption of Cd (II) by green coconut shell powder*, *Minerals Eng*, 19 (2006) 380-387.
- [45]. Prasad, M.N.V., Freitas, H., 2000. Removal of toxic metals from solution by leaf, stem and root phytomass of *Quercus ilex L.* (holly oak). *Environmental Pollution* 110, 277-283.).
- [46]. Reddad, Z., Gerente, C., Andres, Y., Thibault, J.F., Le Cloirec, P. (2003). Cadmium and lead adsorption by a natural polysaccharide in MF membrane reactor: experimental analysis and modelling. *Water Research*. 37: 3983-3991.
- [47]. Revathi M. *Journal of Environmental & Engg.* (2005), 47, 1.
- [48]. Rittmann, B.E., *Journal of Environmental Engineering*, Vol. 136, No.4, 2010, pp.:348- 353.
- [49]. Rao, M., Parwate, A.V. and A.G. Bhole (2001). Uptake of nickel from aqueous solution using low cost adsorbent, *Enviromedia*, 20 (4), 669-675.
- [50]. Sajwan K. S., W. H. Ornes, T. V. Youngblood, A. K. Alva, *Wat. Air Soil Polution.*, A. K. Alva, *Wat. Air Soil pollution.*, 91 (1996) 209-217.
- [51]. Satpathy D, (2002). Optimisation of recovery processes of metal ions using granular activated carbon, ph.D thesis, Nagpur, India.
- [52]. Sharma, I. and Goyal, D. (2009). Chromium (III) removal from tannery effluent by *Streptomyces sp.* (MB2) waste biomass of fermentation process. *International Journal of Integrative Biology*. ISSN 0973-8363.
- [53]. Sharma, I. and Goyal, D. (2010). Adsorption kinetics: Bioremoval of Trivalent chromium from Tannery effluent by *Aspergillus sp.* Biomass. *Research Journal of Environmental sciences*. 4(1):1-12.
- [54]. Shah B.A., A.V. Shah and R.R. Singh, 2009. Sorption isotherm and kinetics of chromium uptake from waste water using natural sorbent material *International Journal of Environmental Science and Technology*, 6(1):77-90.
- [55]. Samad, A., Rahman, M.A. and Alam, A.M.S. (2010). Removal of Arsenic from ground water with low cost multilayer media. *Pakistani Journal Anal Environmental Chemistry*. 11 (1): 28-35.
- [56]. Sud D, Garima Mahajan, MP Kaur. Agricultural waste material as potential adsorbent for sequestering heavy metal ions from aqueous solutions- A review *Bioresource Technology* 99 (2008) 6017-6027.
- [57]. Shukla, S.R., Pai, R.S., 2005. Adsorption of Cu(II), Ni(II) and Zn(II) on modified jute fibres. *Bioresource Technology* 96,1430-1438.).
- [58]. Srivastav V C, Mall I D, and Mishra I M (2009). *Chem Eng. Process.* 48,370.
- [59]. Tang P L Lee CK, Low K S, and Zainal Z, *Sorption of Cr (IV) and Cu (II) in aqueous solution by ethylenediamine modified rice hull*, *Environ Technol*, 24 (2003) 1243 1251
- [60]. Vaughan, T., Seo, C.W., Marshall, W.E., 2001. Removal of selected metal ions from aqueous solution using modified corncobs. *Bioresource Technology* 78 (2), 133-139.)
- [61]. Verma, B., Shukla, N.P., 2000. Removal of nickel(II) from electroplating industry by agrowaste carbons. *Indian Journal of Environmental Health* 42 (4), 145-150.).
- [62]. World Health Organization, WHO (1991). *Nickel. Environmental Health Criteria*. 108, p.383.
- [63]. Zhang, L., Zhao, L., Yu, Y. and Chen, C. (1998). Removal of lead from aqueous solution by non living *Rhizopus nigricans*. *Water Research*. 32: 1437-1444.