Activated Sludge Process For Heavy Metal Removal With Emphasis On Nickel : A Summary On Research And Studies

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Abstract— **Heavy metal removal from waste water can be carried out by various biological and non biological methods. Methods such as adsorption, ion exchange, membrane separations and activated sludge process are often used for heavy metal removal. Activated sludge process is effective and environment friendly. Its serves the purpose of treating waste by using waste and hence minimizing the solid waste problem. Various investigators have studied activated sludge process for removal of heavy metals. They have studied the effect of affecting parameters and isotherm and kinetic aspects of metal uptake. The current review is aimed at summarizing the research and studies on heavy metal removal for investigating the effectiveness and affecting parameters.**

Keywords- **Industrialization, pollution, waste water, heavy metal, treatment methods, biological treatments**.

I. INTRODUCTION

Rapid Industrialization is the need of developing countries because of ever increasing population. The chemical industry is back bone of the manufacturing and processing industries. The main objective behind the industrialization is sustainable development. The energy conservation and environmental protection are two key aspects of sustainable development [1,2,3,4]. Waste water treatment is becoming very important factor because of its effect on man and environment. Also nowadays the recycling of effluent is gaining importance because of water scarcity in various regions of the world [5,6,7]. The industries such as plating, catalyst, mining, paint, pigment, steel etc. emit heavy metals through their exhaust. The effluent containing heavy metals affects adversely the ecosystem. Various acute and chronic diseases are caused by presence of heavy metals in water [8, 9, 10]. It can be removed by various methods like physical, chemical and biological. Physical methods include settling and screening. Heavy metals are chemically treated by precipitation, coagulation and flocculation[11,12,13].The biological methods for heavy metals includes suspended growth processes. Biological methods includes activated sludge, aeration and attached growth processes like trickling filters, bio-towers. The current review is aimed at summarizing the research and studies on heavy metal removal for investigating the effectiveness and affecting parameters.

II. SUMMARY OF RESEARCH ON HEAVY METAL REMOVAL BY ACTIVATED SLUDGE

Atkinson et.al. conducted experiments for waste sludge remediation in fully mixed reactors on a batch basis[14]. They collected waste sludge sample on a weekly basis from the drying beds of a water-treatment facility. They conducted biosorption and desorption experiments for activated sludge. According to their studies, metal loading affected competitive adsorption than chemical characteristic. They observed that the heavy metals present in high concentration are preferentially adsorbed on activated sludge. Mineral acids can be used for desorption of heavy metals from activated sludge. Abdolmaleki et. al. studied the preparation of conductive polypyrrole (PPV). They studied adsorption capacity of adsorbent for nickel removal from aqueous solution[15]. They compared various adsorbents with conductive electro-active polypyrrole composite for removal of heavy metals . Adsorbents such as anthracite, activated carbon and purolite were used. Their capability of separating nickel from aqueous solution was examined. They carried out studies aimed at examining the effects of various factors. The factors studied in their investigation were pH of solution, dosage of adsorbent and contact time. Comparative studies were done for anthracite, purolite and activated carbon. This study indicated that removal percentage decreased by increasing concentration of adsorbent. Alkaline nature of the solution favors metal removal.

Ong et. al. carried out studies aimed at investigating the capacity of activated sludge and dried sludge to adsorb the heavy metals[16]. They also studied the effect of powdered activated carbon and dried sludge to

reduce the toxic effects of heavy metals. The removal of heavy metals was rapid in first 30 minutes and attained steady state in 5 hours. The specific oxygen uptake rate (SOUR) is indicator of the inhibitory effects of heavy metals on the microorganism activity in an activated sludge. It is estimated by following formula.

SOUR□60G =X (mg O_2/g MLSS.h)

Where G is the slope of the linear portion of the DO decline curve in mg $l^{-1}min^{-1}$ and X is the MLSS concentration in g/l. They concluded that activated sludge showed better adsorption capacity of Cr and Cd than powdered activated carbon. Dried Water Hyacinth (Eichhornia Crassipes*)* was used for nickel removal by Hashim[17]. He studied nickel removal with parameters like biosorbent dosage, contact time, pH and temperature. He prepared synthetic solution of nickel in the form of 10 g/l of $NiSO_4.6H_2O$. Optimum adsorbent dose was observed to be 3 g/l. 90 percent nickel removal was obtained by him in 50 minutes. Optimum pH value of was observed to be 6 and temperature 35^0C.

Most of the research on heavy metals removal in biological systems has been directed towards the suspended growth activated sludge process. One such review was carried out by Gunatilake[18]. According to this review, activated sludge process is one of the efficient and effective methods for nickel removal. It is the most common option, which uses microorganisms in the treatment process. The microorganism breaks down organic material with aeration and agitation. Then solids were alllowed to settle out. Bacteria-containing activated sludge is continually re-circulated back to the aeration basin. This helps to increase the rate of organic decomposition. Dhokpande and Kaware carried out review on biological methods for heavy metal removal [19]. Their review indicates that about 70 to 90% removal of heavy metal by activated sludge is possible. The heavy metal removal by activated sludge involves physical adsorption as well as biological activity. Dried sludge can be used for biosorption. The wet sludge normally uses biological phenomena such as decomposition with heavy metals. Similar review was carried out by Varma.et.al. [20]. They compared the removal of heavy metals by adsorption using fly ash and sludge. Hartmann et. al. worked on the toxicity effect of heavy metals on activated sludge microorganisms with the help of the respiration inhibition tests. Respirometry is a more direct method for measuring sludge activity and toxicity to sludge [21]. The most common way of measuring the bacterial respiration rate is the oxygen uptake. The nitrifying micro-organisms are more susceptible to heavy metal inhibition than the micro-organisms responsible for the oxidation of carbonaceous material. All investigated heavy metals inhibit activated sludge growth at relatively low concentrations. However, the critical concentrations are only achievable by shock loads. Above this concentration, they significantly affect activated sludge respiration. As with many heavy metals, adaptation can significantly increase microbial tolerance to heavy metals. The need for monitors of influent waste water toxicity at municipal WWTPs has been demonstrated. It can be concluded that for the needs of process control early detection of metals allows the quick intervention of appropriate control strategies. This serves the purpose of reducing the biomass-toxicant contact time together with respiration inhibition. Colussi et. al. worked on effects on methane production with removal of nickel by sorption on anaerobic sludge[22]. They investigated biosorption of Ni (II) on industrial anaerobic sludge at 308.1 K and 7.5 pH in a batch reactor. They observed that the effective metal sorption capacity of anaerobic sludge was 10.25 mgNi/gTSS. Freundlich isotherm was obeyed by nickel uptake . Their results revealed that methane production rapidly drops for low metal concentration. Percentage nickel removed was observed to be 98.3 percent.

Alasl and Beiki used moving bed biofilm bioreactor for heavy metal removal from waste water[23]. They obtained 85 percent COD removal and 33 percent nickel removal in their studies. Increase in initial concentration brought about 30 percent increase in nickel removal. Niec and Cha carried out an investigation on influence of anoxic selectors on heavy metal removal by activated sludge[24]. They compared the metal binding characteristics of an anoxic selector activated sludge system and a conventional activated sludge system. They observed that selector sludge had significantly higher sorption capacity than the control sludge. The selection of the ECP-producing bacteria (*i.e.*, Zoogloea sp.) by the selector system may be the reason for this. Dhokpande et.al. reviewed the heavy metal treatment by activated sludge. This review indicated that activated sludge has been used for the heavy metal treatment efficiently by many researchers [25]. Maximum removal efficiency of 95 percent was obtained during various studies. They concluded that the efficiency of removal can be increased by techniques such as immobilization and use of anoxic selectors.

III. CONCLUSION

Various physical, chemical and biological methods for heavy metal removal are being explored by various investigators. The removal percentage of heavy metals by these methods varies from 30 to 90 percent. New methods with various low cost materials for sorption and biological removal of heavy metals are being tried. Reduction in cost, use of low cost sorbents, environmental friendly treatment and generation of lesser waste sludge or material are driving factors for investigation on new and advanced methods. Activated sludge has been

used for various investigators for removal of heavy metals. Heavy metal removal more than 90 percent was obtained by various investigators. The removal of heavy metal by activated sludge can be described by sportive phenomenon as well as biological decomposition. Few study indicated encouraging results for desorption of heavy metals. This review summarizes heavy metal removal and related research. It was focused on nickel removal from future research point of view. It can be concluded that activated sludge, dry or wet can be effectively utilized for heavy metal and hence nickel removal.

REFERENCES

[1] Sunil J. Kulkarni, "Studies and Research on Friction, Friction Factor and Affecting Factors: A Review", International Journal of Engineering Sciences & Research Technology, vol.3, no.10, pp. 355-359,Oct.2014.
[2] Sunil J. Kulkarni, "Tidal Energy: A Review", International Journal of Research (IJR), vol.2, no.1, pp.55-58, January 2015.
[3] Toshi H. Arimura Kazuyuki Iwata, Measures to Protect the Environment and Conserve Energy Taken by the United States and Japan: Review of Quantitative Analysis", Far eastern studies, vol 9, pp.65-87,2010.
[4] Y.P.Bhalerao, S.V.Patil,P.V.Vijay Babu, S. J. Kulkarni, "Energy Retrofit Studies in Diethyl Thiophosphoryl Chloride (DETC) Plant" International Journal of Chemical Engineering Applications, vol.2, no.6, pp.439-444, Dec.2011
[5] Sunil Kulkarni, "Recycle and Reuse of Water- A Review", International Journal of Research (IJR), vol.1, no.11, pp. 802-805, December 2014.
[6] Kirsten Exall, "A Review of Water Reuse and Recycling, with Reference to Canadian Practice and Potential: 2. Applications", Water Qual. Res. J. Canada, vol. 39, no. 1, pp.13–28, 2004.
[7] Yaziz MI, Gunting H, Sapari N, Ghazali AW, "Variations in rainwater quality from roof catchments", Water Res., vol.23, no.6, pp.761–765, 1993.
[8] Sunil Kulkarni, Jayant Kaware, "A Review on Health Effects of Phenol", International Journal of Research (IJR), vol. 2, no.5, pp.968-973, May 2015.
[9] Sumit Chibbar, Nandini Sharma, "A Review on Impact of Heavy Metal Toxicity on Environment", Int. Journal of Innovative Research and Studies, vol.3, no.5, pp.530-541, 2014.
[10] Sunil J. Kulkarni, Sonali R. Dhokpande, Dr.Jayant P. Kaware, "A Review on Studies on Effect of Heavy Metals on Man and Environment", International Journal for Research in Applied Science and Engineering Technology, vol.2, no.10, pp.227-229, 2014.
[11] Mudassir Ahmad Bhat, Faizanul Mukhtar, Hamida chisti, Shakeel Ahmad Shah, "Removal Of Heavy Metal Ions From Waste Water By Using Oxalic Acid: An Alternative Method", *International Journal of Latest Research in Science and Technology*, vol.3 no.3, pp. 61-64, May-June 2014.
[12] Mohamed Osman Awaleh and Youssouf Djibril Soubaneh, "Waste Water Treatment in Chemical Industries: The Concept and Current Technologies", *Hydrol Current Res*.,vol. 5 no. 1, pp.1-12, 2014.
[13] Krystyna Kosińska, Tadeusz Miśkiewicz, "Precipitation Of Heavy Metals From Industrial Wastewater By Desulfovibrio Desulfuricans", *Environment Protection Engineering*, vol. 38 no. 2, pp.51-60, 2012.
[14] BW Atkinson, F Bux and HC Kasan, "Waste activated sludge remediation of metal-plating effluents", Water SA, vol. 24 no. 4, pp. 355-359, October 1998.
[15]Aliyeh Yousefi Abdolmaleki, Hossein Eisazadeh, Zahra Taghipour, Marjan Tanzifi, " Effect Of Various Agents On Removal Of Nickel From Aqueous Solution Using Polypyrrole As An Adsorbent", Journal of Engineering Science and Technology, Vol. 7, No. 5 , 540 – 551,2012.
[16] Soon-An Ong, Eiichi Toorisak, Makoto Hirat, Tadashi Hano, "Adsorption and toxicity of heavy metals on activated Sludge", ScienceAsia, vol. 36, pp.204–209, 2010.
[17] Norhaslin Binti Hashim, "Removal Of Nickel From Aqueous Solution By Using Dried Water Hyacinth (EICHHORNIA CRASSIPES)", Faculty of Chemical Engineering and Natural Resources University, Malaysia Pahang MAY 2008.
[18] Gunatilake S.K., "Methods of Removing Heavy Metals from Industrial Wastewater", Journal of Multidisciplinary Engineering Science Studies (JMESS), vol. 1, no. 1, pp.12-18, November – 2015.
[19] Sonali R. Dhokpande, Dr. Jayant P. Kaware, "Biological Methods for Heavy Metal Removal- A Review" , International Journal of Engineering Science and Innovative Technology (IJESIT), vol. 2, no.5, pp.304-309, September 2013
[20] Geetha Varma.V, Dr.Ram Karan Singh and Vaishali Sahu, "A comparative study on the removal of heavy metals by adsorption using fly ash and sludge: A review", International Journal of Application or Innovation in Engineering & Management, vol. 2, no. 7, pp.45-56, July 2013.
[21] Silvie Hartmann, Hana Skrobankova, Jarmila Drozdova , "Inhibition of activated sludge respiration by heavy Metals", Proceedings of the 2013 International Conference on Environment, Energy, Ecosystems and Development, pp.231-235, 2013.
[22] I. Colussi, A. Cortesi, V. Gallo, D. Solinas, R. Vitanza , "Removal of Nickel by sorption on anaerobic sludge Effects on methane production" DICAMP, Department of Chemical, Environmental and Raw Materials Engineering, University of Trieste. Piazzale Europa, 1 – 34127 Trieste, ITALY.
[23] Morteza Kashefi Alas, Sepideh Agha Beiki , "The Study of Removal of Heavy Metals (Nickel & Chrome) of Industrial Wastewater Using MBBR (Moving Bed Biofilm Bioreactor)" , Journal UMP Social Sciences and Technology Management, vol. 3, no. 3, Supp. 1, pp.297-303, 2015.
[24] Jay H. Niec and Daniel K. Cha, "Influence of Anoxic Selectors on Heavy Metal Removal by Activated Sludge", Biotechnol. Bioprocess Eng., vol. 5, pp. 431-435, 2000.
[25] Sonali Dhokpande, Dr. Jayant Kaware, Sunil Kulkarni, "Activated Sludge for Heavy Metal Removal-A Review", International Journa l For Res Earch In Applied Sciencce And Engineering Technology, vol. 2, no.7, pp.254-259, July 2014.