Reduction of Nitrate From Sewage Using Steel Slag

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Abstract- *Now a days there is lot of scope in using low cost adsorbents which are obtained from agricultural wastes and industrial wastes for the removal of contaminants such as nitrate, phosphate, fluoride and many more. In this study we utilized industrial waste such as steel slag as a low cost adsorbent for the removal of nitrate from wastewater. Steel slag which is considered as a waste product from the steel making industries is used for the removal of nitrate from sewage. Since nitrate presence in sewage has detrimental effect on human health as well as to the environment, it should be removed. Adsorption method of nitrate removal can prove to be most economical technique in removing nitrate and hence we used adsorption method of nitrate removal. It was found from the study that steel slag can remove the nitrate from sewage. From our study we found that the maximum removal of nitrate is found to be 31.31% at a calcination temperature of 800^{0}C at a mass ratio of 6:4:0.9. We also found that the pH has influenced the removal of nitrate and as such we found that in acidic range the removal was found to be maximum. Also the contact period of not less than 4 hours found to be the best reaction time for maximum removal of nitrate. We also found that the surface area had an effect on the removal of nitrate and as such as the surface area increases removal of nitrate also increases.*

Keywords- Modified steel slag, nitrate, reaction time, pH, calcination temperature.

I. INTRODUCTION

In recent days, the sources of water viz. surface sources and subsurface sources are highly contaminated by nitrates which is very harmful to the human beings as well as to the environment. Nitrate concentration in surface waters and ground waters have increased substantially over the last 30 -40 years. Particularly wells in the agricultural areas are more prone to nitrate contamination as their concentration levels frequently crossing the WHO guideline value of 10 mg/l. Nitrogen may be present in the form of nitrate or ammonia. Since the concentration of ammonia is very low it is the nitrate which cause more harmful to the environment and human health. Nitrate is the most highly oxidized form of nitrogen compounds mainly present in natural waters as it is the product of decomposition of organic nitrogenous matter. Nitrate contamination has spread all over the globe, countries and regions. Whenever the concentration of the nitrate increase above its threshold it causes lot of damage to the human beings and environment. The main reasons for the increase in the concentration of the nitrates are continuous increase of industrial effluent, increase in the domestic sewage, utilization of chemical fertilizers in agriculture, urbanization, increase in population, decayed vegetable and animal waste, leachates from refuse dumps and atmospheric washout and etc… Even though nitrates have been defined as the non-objectionable final end product in aerobic treatment of sewage, yet its concentration in potable waters are controlled, because larger concentration (above 45 ppm) may cause nitrate poisoning in infants. The increase in the concentration of the nitrates directly affects the human population by causing cancer and it has been found that increased nitrate concentration can cause bluebaby disease in infants which is characterized by denied oxygen, causing suffocation in extreme cases. Since suffocation or lack of oxygen causes the body turn bluish, it may lead the child to turn blue. This disease is technically called methaemoglobinemia. Increased nitrate concentration in lakes can cause Eutrophication which causes oxygen depletion in the water bodies hence aquatic life may not get proper oxygen for survival. And if the water body got eutrophicated then there will be no proper penetration of the light deep into the water bodies. If the surface waters are used as the source of drinking and if it is contaminated by nitrate, it directly affects the human and animal life. To protect human life and also surrounding environment it is necessary to decrease or to treat the wastewater for reducing the nitrate concentration before letting it into the water bodies. Since human waste contains nitrate it is impossible to remove nitrate sent percent. There are several ways by which nitrate can be removed viz.adsorption, absorption, denitrification, chemisorption and etc.. Among all the methods available adsorption proves to be economical, simple method. Many materials are available for removing nitrate from water or from aqueous medium and as such the general methods or materials used for this technique are chitosan, activated carbon, ion exchange resin and sepiolite but usage of these materials proves to uneconomical and complex and hence they are not suitable for remedying huge quantity of polluted water. Among different available adsorbents steel slag is used as adsorbent in this study.

Sample collection: The sample of sewage was collected from local sewage treatment plant which receives domestic sewage from Davangere city. It has a 20 MLD capacity. The sample was collected mainly from the inlet chamber and hence the sewage was at its untreated condition usually known as raw sewage. The sewage was collected between 11 AM to 2 PM with the proper equipment that is provided in the treatment plant.

For conducting this study, steel slag was obtained from Jindal Steel Works Ltd. Toranagallu

II. METHODOLOGY

A Preparation of original steel slag:

For conducting this study, steel slag was obtained from Jindal Steel Works Ltd. Toranagallu. Initially the steel slag was converted into fine particles by repeated crushing, grounding and sieving. For conducting this study the required fine sizes are 0.3mm. Hence we utilized the material passing through sieve size 0.3mm. With the help of Jaw crusher we are able to ground the steel slag into our desired size. Once after achieving the desired size slag, the steel slag was washed with distilled water. Washing is done because of the fact that the surface of the steel slag (adsorbent) should be clean as adsorption is a surface phenomenon. After washing the steel slag it has to be dried in a Hot Air Oven where temperature should be kept 108^0C for 3 to 4 hrs. Then the samples are cooled to room temperature. This above prepared steel slag is called Original Steel Slag.

B. Preparation of Modified steel slag or Adsorbent:

In this study it is the modified steel slag which acts as adsorbent but not the original steel slag. Hence the original steel slag is slightly modified to get desired adsorbent. The dry slag or original steel slag, distilled water and aluminum hydroxide were utilized for making modified steel slag and the procedure is explained below:

The dry slag or original steel slag, distilled water and aluminum hydroxide were thoroughly mixed at room temperature with defined mass ratios as five groups. Here for this study we have utilized the mass ratio as 6:4:0.3, 6:4:0.6, 6:4:0.9, 6:4:1.2, 6:4:1.5. Once after preparing above said mixes they has to be aged at room temperature for not less than 15 hrs and after that they has to be cooled or dried in Hot Air Oven at 108^0C temperature. Since adsorption increases with temperature and in order to increase the adsorption capacity of adsorbent it has to be heated in high temperature. For that, once the samples are taken from the oven they were heated at high temperatures like 600^0C, 700^0C, 800^0C and 900^0C with above said mass ratios respectively in a muffle furnace. When the samples are taken back from the muffle furnace they were cooled in room temperature. Now 2g of adsorbent from each mass ratio for specific temperature is measured and taken in 250ml capacity conical flask. For this conical flask we have to add 100ml of sewage and then they were agitated thoroughly and kept in room temperature for not less than 3hrs. Here for this study we collected the sewage sample from 20MLD Sewage Treatment Plant which is situated in Davangere. During this duration the nitrate in the sewage is thoroughly adsorbed by the adsorbent and after this the samples are checked for nitrate detection.

During this study the chemicals used are of analytical grade. Potassium nitrate is utilized for preparing stock solution and from that desired concentration of standard solutions were prepared.

III. RESULTS & DISCUSSIONS

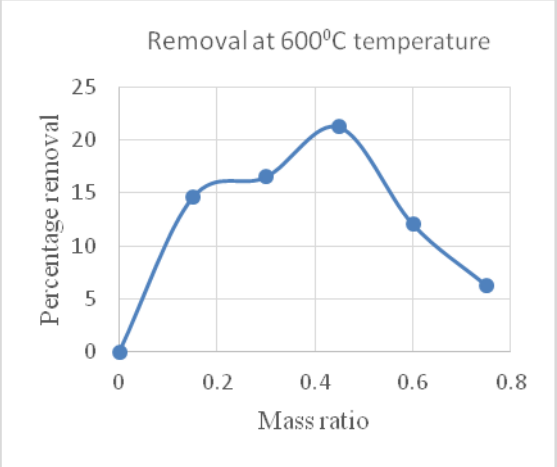

Fig.1 Graphical Representation Nitrate removal at 600^0C temperature

From the above graph it is clear that the removal of nitrate goes on vary from minimum of 6.29% to maximum of 21.25%. The minimum removal took place at mass ratio 6:4:1.5 and similarly maximum removal took place at mass ratio 6:4:0.9. Initially the reduction in nitrate is incresinng from 14.59% and reach maximum of 21.25% and again the reduction in nitrate decreases to 6.29%.

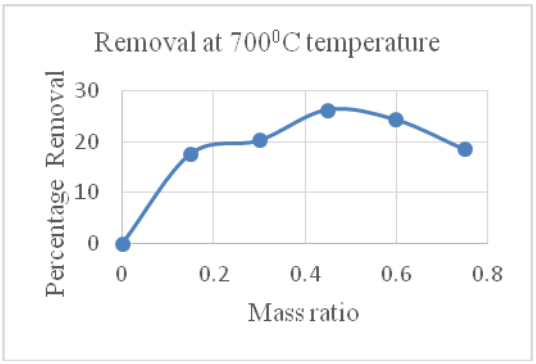

Fig.2 Graphical Representation Nitrate removal at 700^{0}C temperature

From the above graph it clear that the maximum removal of nitrate was found to be 26.28% and it occurs at a mass ratio of 6:4:0.9 and similarly minimum removal of nitrate was found to be 17.63% and it occurs at a mass ratio of 6:4:0.3.

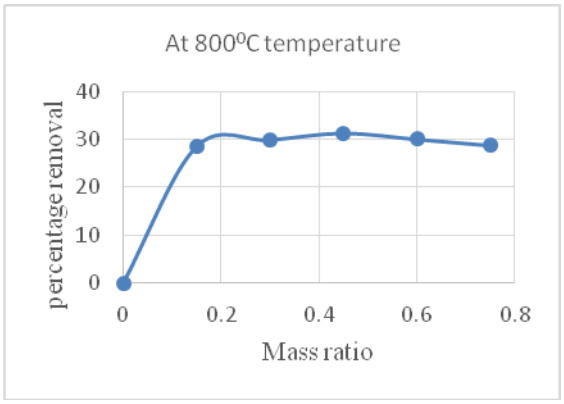

Fig.3 Graphical Representation Nitrate removal at 800^{0}C temperature

Here the maximum removal was found to be 31.31% at a mass ratio of 6:4:0.9 and the minimum removal was found to be 28.57% at a mass ratio of 6:4:0.3.

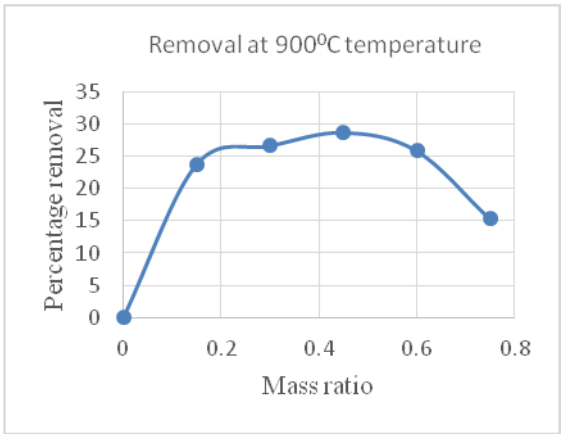

Fig.4 Graphical Representation Nitrate removal at 900^{0}C temperature

As seen from the graph it is clear that the minimum nitrate removal was found to be 15.26% at a mass ratio of 6:4:1.5 and maximum removal was found to be 28.68% at a mass ratio of 6:4:0.9

A. Effect of pH

pH is nothing but the measurement of hydrogen ion concentration in an aqueous solution and it is measured as negative logarith to the base ten of the hydrogen ion concentration. It is very important to study the pH of the sewage before and after the treatment in this study because the adsorption process is mainly depends upon the pH. Efficiency of certain treatment methods mainly depends on the pH of the solution.

Fresh sewage will be slightly alkaline in nature and as such the pH of the sewage collected from the sewage treatment plant was found to be 7.13. As the age of the sewage increases pH will fall because of the production of acids. Here in this study the pH of the sewage plays an very important role. In this stydy during the treatment the pH of the sewage was maintained between 6 to 6.5 and we found that the efficiency was better than the that of the treatment with pH slightly above 7.

B. Effect of Temperature

Temperature also plays an important role in adsorption process as temperature activates the surafces of the adsorbent. It is found that temperature of sewage is slightly more than that of the water. In this study for effective removal of nitrate from sewage we utilized a higher temperature and we achieve this temperature by electrical muffle furnace. Here we heated the adsorbents at higher temperatures such as 600^{0}C, 700^{0}C, 800^{0}C and 900^{0}C.

From the graph it is clear that the removal of nitrate goes on increases with temperature and reaches its maximum and with further increase in the temperature decreases the efficiency of nitrate removal. It is also found that the maximum nitrate removal occurred at a temperature of 800^{0}C and the efficiency was found to be 31.31%

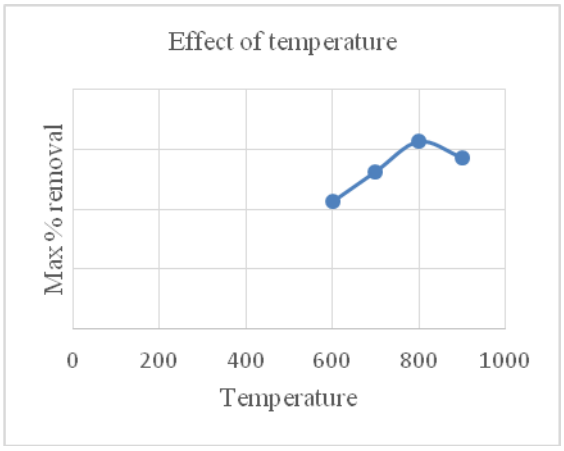

Fig.5 Graphical Representation showing effect of temperature on Nitrate removal

IV. CONCLUSIONS

From the above study it can be concluded that steel slag can be used as an effective adsorbent for the removal of nitrate from sewage. From previous study it can be shown that slight modification in surface of steel slag using modifying agent such as aluminium hydroxide it is possible to improve or increase the adsorption capability of steel slag in removing nitrate. From the study it is clear that adsorption of nitrate on steel slag was maximum at 800^0C at a mass ratio of 6:4:0.9. The maximum removal of nitrate from sewage was found to be 31.31%. Temperature plays an very important role in adsorption and as such the maximum temperature at which maximum removal of nitrate occurs at 800^0C.pH had an effective role in removal of nitrate and it is found that when the pH was in acidic range (i.e below 7), the nitrate removal was found to be increased to certain level. It is found that characteristics of adsorbent such as finess also affects the efficiency and as such it is found that adsorption increases with increase in surface area.

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