Recycling of Industrial Effluent: A Study on Recycling Methods

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***ABSTRACT:** Industrial waste is usually understood as the waste product left by the industries when the manufacturing of the product carried out in the industry is accomplished. Now a days because of rapid industrial development a huge quantity of industrial waste is expelled out of the manufacturing plants and as a result of the high quantity of industrial waste which results in mixing of industrial effluents in nearby water body the contamination of drinking water becomes extremely evident. Health issues caused due to drinking of contaminated water mixed with industrial effluents is observed. In order to overcome the health issues, filtered water is consumed to control the health hazards. But, due to high percentage of toxins present in water, complete disinfection of water becomes a challenge. Thus current study provides a means to purify the contaminated water and thus opens a future prospects to provide means to process industrial waste.*

***KEYWORDS:** Effluent, Industrial, Manufacturing, Waste, Water.*

INTRODUCTION

Industrial waste refers to the liquid, solid, or semi-solid material that is left by a manufacturing unit after the process of the manufacturing is accomplished. In order to obtain a particular product, the residues are left as a by-product during the sequential process of manufacturing of the particular product by the manufacturing unit. Usually the manufacturing unit leave the industrial waste to run in the nearby water body which leads to contamination of the water body and also causes serious health hazards to the population residing in the nearby area. Industrial waste is the by-product of a variety of manufacturing industries including automobiles, electronic gadgets, clothing, footwear, processed food, beverages, and many more.

Industrial effluent which includes gases, liquid, and solids stored in containers are divide into two different categories namely hazardous and non-hazardous industrial effluent. The hazardous effluent is the result of many industrial processes including manufacturing. In some cases, hazardous effluents are released by manufacturing units or in some cases an individual person which include paints, pesticides, cleaning fluids. Non-hazardous effluents includes those that does not meet the governing authority's terminology of hazardous effluents. Since the beginning of the industrial revolution, the contaminated industrial waste has been a problem for the environment. As industrial effluents are toxic, corrosive, inflammable, and reactive. Table 1 shows the waste produced by various manufacturing industries. Thus it is required to be managed with caution otherwise the industrial effluent may result in health and other dangerous hazards. Few examples of waste generated by various industries are shown in Table 1.

Table 1: The waste produced by various manufacturing industries as a result of making variety of products

Manufacturing industry	Type of waste produced by the industry
Chemical industry	Spent solvents, Waste product that is reactive, Industrial effluent mixed with organic solvents
Metal industry	Heavy metals, Waste obtained from paints, Released sludge, Heavy metals
Printing industry	Waste ink, Sludge mixed with ink, Heavy metal solutions, Solvents, Heavy metals
Leather industry	Benzene and toluene

Petroleum industry	Hydrocarbon and benzene mixed waste water, Sludge obtained from the refining
Construction industry	Paint waste that is inflammable, Inflammable solvents
Paper industry	Effluents containing heavy metals, Inflammable solvents

1. *Industries producing waste water includes:*

Laundry industry: a high number of industrial waste including waste water left from cleaning towels, cleaning of floor mats, cleaning uniforms is left especially cleaning of door mat leave a lot of oil, grease, heavy metal, sand, lint, grit which results in high quantity of industrial effluent coming out of the laundry industry. Chemical industry encounter a lot of environmental challenges in order to treat the industrial effluents. Petroleum refineries release a lot of industrial effluents involving conventional pollutants like oil, chromium, suspended solids, phenols, sulphides, and ammonia[1], [2].

Food processing and agriculture industry: food processing and agriculture industry release industrial effluents that contain insecticides, pesticides, fertilizers, and animal waste that are required to be organized. The manufacturing process of processed food require flow of water including high concentration of chemicals, organic substance that are soluble in nature and particulate matter. Industrial effluent coming from food processing and agriculture industry include blood, bodily fluid, animal slaughter and processing, intestinal matter and are required to be carefully treated.

Fracking of oil and gas: the waste water coming from the drilling of shale gas is looked as a hazardous waste[3]. The hazardous industrial effluent is salty in nature having a high concentration of sodium dissolved in the effluent. In order to facilitate the process of drilling a high quantity of water having a high concentration of magnesium, barium, manganese, chloride, sodium, iron, strontium, methanol, sulfate and other industrial substrates dissolved in water including a high concentration of chemicals. The water utilised for the purpose of fracking also comprises of hydrocarbons and some toxic hazardous substances including toluene, xylene, benzene, ethylbenzene are extracted as a part of the process of drilling During the process of drilling some radioactive materials that occur naturally are produced along with the industrial effluent and are known as naturally occurring radioactive materials (NORM).

Water treatment plants: the industrial effluent produced by the plants set up to treat the waste water includes hazardous components that are mixed with the water. The treatment of water having hazardous components mixed in it is difficult to purify even by treating through chlorine and may contains residues of haloacetic acids, trihalomethanes dissolved in water. The solid effluent of industry contains organic synthetic compounds usually released from every household, common solids, heavy metals, and bio-solids[4].

Iron and steel production: the industrial effluents are produced by the iron and steel industry is during the manufacturing of steel and iron for the purpose of cooling and during the process of separation of steel and iron. The product obtained during the manufacturing of steel and iron releases industrial effluents like cyanide and ammonia in the initial step. As the process of manufacturing proceeds waste effluents released includes naphthalene, phenol, benzene, anthracene, cresols[5] Water is required as a coolant and base lubricant along with hydraulic oils and particulate solids during the process of conversion of steel and iron rods, sheets, and wires. The galvanization process of steel requires water along with sulfuric acid and hydrochloric acid.

Power plants: the power plants produce industrial effluents in a large quantity and constitutes effluents coming from fossil-fuel power stations especially coal mining plants The power plants release industrial effluent having a high concentration of cadmium, lead, arsenic, mercury, chromium, selenium, nitrogen compounds particularly nitrites and nitrates. Few industries releasing air pollutants release the captured pollutants to the waste water stream.

Mining and Extraction Industry: In mining and extraction industry the mine tailing is the industrial effluent left after the finely grounded rock is separated after performing the mining operations of the mineral concentrate including silver and gold are removed. Efficiently handling the mine tailing coming out of the mining industry is the responsibility of the every manufacturer dealing with mining and extraction. Proper treatment of the industrial mine tailing reduces the requirement of tailing ponds.

Finishing of metal: the waste water released as an industrial effluent from the metal finishing industry is usually a thick semi solid matter know as slurry. The industrial effluent comprises of metal pieces dissolved in liquid, metal hydroxide like magnesium hydroxide, zinc hydroxides, nickel hydroxides, ferric hydroxides, aluminium hydroxides, copper hydroxides. Metal finishing industry includes metal plating, finishing of metal, printed circuit board (PCB) manufacturing industries. The industrial effluent produced by metal finishing industry is treated following the environmental guidelines to not harm animal, human beings and plants

REVIEW OF LITERATURE

Yunting and Yudong conducted a study on electrochemical redox mediation which is environment friendly for the process of extraction of metal which requires high cost obtained from the waste material coming out of the industries. The process of the metal extraction by means of the electrochemical process and the recovery from the waste obtained from the effluents coming out of the industries are required for improving the reduction in the hazards caused to the environment and maintaining sustainability. The study focuses on various electrochemical processes obtained from the variety of industrial wastes. The electrochemical redox mediation in this process contributes a vital role as it includes and promotes redox mediation from H_2O/O_2/additives. According to this, the direction, design of electrochemical process, selection of electrochemical reactor, design of suitable redox pairs, and fabrication of electrode material is done. By using waste-free strategy of the green-electrochemical process of the extraction particularly beneficial for the recycling of expensive metals that are carried out to remove waste producing chemical redox reagents.

Svetlana et al. conducted a study in the support of circular economy that is based on recycling technological cycle in steps of the industrial waste. The circular economy is one of the vital component of the development of the society and the manufacturing sector as a whole and faces challenges to existing accounting system. In today's situation, the transition of the industrial economy from industrial to post industrial economy, the issue in maintaining a suitable environment and necessary use of naturally obtained resources need a suitable methodology depending on the recreation and sustainably utilise the natural resources and not just to earn maximum monetary benefit from the natural resources. Now a days, there is no fix and efficient system to take care of the industrial waste, which will include solving the work based on circular economy. The research involves finding a system to implement in recycling of industrial waste by means of a five stage process[6].

Dan li et al. conducted a study on the treatment of waste obtained from the industry and efficiency of the process of recycling depending on the two stage data envelopment analysis DEA with undesirable inputs. Globally, it is the goal of every country that to achieve a environment friendly and a resource saving supply chain while carrying out the development of the economy. Since China is coming out as a growing nation in terms of industry, pollution arising from the industrial waste is a serious concern. Researchers have worked on the processing of waste a lot and now, they are working towards increasing the efficiency of the policies involved in the treatment of the waste material obtained from the industries. The research puts a model to assess the efficiency of the recycling of the waste material obtained from the industry its reuse, involving water gas, solid waste, and waste water from various cities of China. The model suggested is based on the circular economy structure proposed by the Environment Protection Institute of China. The results showed that integrated efficiency of the waste obtained from the industry was stable for a period of 5 years and the efficiency at the pollution disposal stage was more in comparison to the efficiency at resources re usage and the efficiency at the pollution disposal was also observed to be increased. The research does not provide a means to process industrial waste so as to clean the industrial effluent

METHODOLOGY

In order to determine the efficiency of the process carried in order to purify the waste water coming out the manufacturing industry and to make the water pure to be consumed by the population residing in the nearby area of the manufacturing industry, a questionnaire form was distributed in the area and the population residing in the area was asked to fill the questionnaire form. All the candidates consuming contaminated water for more than 6 months were selected to carry out the survey. The form was filled in order to determine the effectiveness of the process carried out to purify the contaminated industrial effluent and the effect observed by the population residing in the nearby locality belonging to varied age group upon consuming the water which was earlier contaminated and later purified by a series of successive steps to make the contaminated water potable for the nearby population residing in the area where the manufacturing industry was established. A group of 90 people was picked to carry out the survey and out of these 90 people few were belonging to 10 to 20 years of age group whereas other were belonging to 20 to 40 years of age group and rest participants

were of more than 40 years of age group to 70 years and the effect of consuming processed water on all the participants was analysed as a part of the study. Table 2 shows the questionnaire form distributed among the population group residing in the area where the manufacturing industry is established in order to determine the effect of consuming processed industrial effluent on the health of the population group.

Table 2: Shows the questionnaire form distributed among the population group residing in the area where the manufacturing industry is established

Name: Age: Sex: Occupation:	
Do you feel change in taste of your regular tap water?	Yes: No:
Did you face any health issue after consuming contaminated water?	Yes: No:
What all health issues you faced after consuming contaminated water?	Typhoid fever: Cholera: Giardia: Dysentery: Escherichia Coli (E.coli): Hepatitis A: Salmonella:
Do you purify water before consuming industrial effluents mixed contaminated water?	Yes: No:
What effect you observed after consuming processed water aimed to remove industrial impurities.	Comment:

All the candidates residing in the nearby area of the manufacturing unit and who had participated in the survey were asked to consume processed industrial effluent for a period of 3 months. In order to determine the

effectiveness of the process which involves the purification of the industrial effluent so as to provide the population residing in the nearby locality a pure form of water which is toxins free and is processed in a way to provide the population a contamination free drinking water. Removal of contaminants from the industrial effluents is carried so as to prevent mixing of impure industrial effluents in the nearby water body. The mixing of industrial effluents in the nearby area. The process of the purification of the industrial effluent is carried out in steps which involves: aerobic treatment of industrial effluent, ion-exchange treatment of industrial effluent, and anaerobic treatment of industrial effluent.

RESULT AND DISCUSSION

Industrial waste is usually termed as the waste released by any manufacturing plant during the process of manufacturing of the desired item. Industrial effluent released by many industries contaminate the nearby water body and eventually causes health hazards to the population residing in the nearby area. There are many ways to de contaminate the contaminated industrial effluent. Present study involves the water purification by three steps namely, aerobic treatment of industrial effluent, Anaerobic treatment of industrial effluent, and, Ion exchange treatment of industrial effluent.

The result of the study conducted on a total 90 candidates living in the area where most of the manufacturing industries area established. Due to many manufacturing industries established in the area the population residing in the area consume contaminated water. The contamination of drinking water is done by mixing the industrial effluents coming out of the industries into the nearby water stream. By mixing the industrial effluent in the nearby water stream the water gets contaminated and as a result of contamination the population consuming the same water frequently fall ill. Many people who are not aware of the contamination of water, drink the contaminated water assuming the water to be pure drinkable water. But, on facing frequent illness and health issues they consult physician or follow some other therapy to treat their illness caused due to consumption of contaminated water. The survey is conducted to determine the effectiveness of the water purification method suggested to treat the contaminated water coming out of the manufacturing industries.

The water treatment plan includes aerobic treatment of industrial effluents, anaerobic treatment of industrial effluents, and ion exchange treatment of industrial effluents. By following the three step purification of the industrial effluents mixed water, the pure water obtained was checked for the purification. The population living in the nearby area was allowed to consume the treated water instead of directly consuming the untreated water for a period of three months and then asking every candidate regarding the health status of every candidate who consumed treated and purified water for a period of three months.

To test the purification level of treated water a survey was conducted on a total of 90 candidates. All the 90 candidates were divided in three groups of 30 candidates each group A, group B and group C and each candidate was asked to consume purified water for a period of three months. Out of group A, candidates who suffered from typhoid fever was observed to be zero. In group A, candidate who suffered from cholera was seen as zero. Candidate who suffered from giardia in group A was 1 and 29 candidates did not fall ill due to giardia. Survey candidate who suffered from dysentery in group A was 1 and 29 candidates did not fall ill due to dysentery. In group A, the number of candidates who suffered from Escherichia Coli was observed to be zero, in group A, candidates who suffered from Hepatitis A was observed to be zero and candidates who suffered from Salmonella in group A was zero.

Group B candidates who suffered from typhoid fever was observed to be 1 and 29 candidates did not suffer from typhoid fever. In group B, candidate who suffered from cholera was seen as zero. Candidate who suffered from giardia in group B was 2 and 28 candidates did not fall ill due to giardia. Survey candidate who suffered from dysentery in group B was 1 and 29 candidates did not fall ill due to dysentery. In group B, the number of candidates who suffered from Escherichia Coli was observed to be zero, in group B candidates who suffered from Hepatitis A was observed to be 1 and 29 candidates did not fall ill due to Hepatitis A and candidates who suffered from Salmonella in group B was observed to be zero.

Group C candidates who suffered from typhoid fever was observed to be zero. In group C, candidate who suffered from cholera was seen as 1 and 29 candidates did not suffer from Cholera. Candidate who suffered from giardia in group C was zero. Survey candidate who suffered from dysentery in group C was zero. In group C, the number of candidates who suffered from Escherichia Coli was observed to be 1 and 29 candidates

did not fall ill due to Escherichia Coli, in group C, candidates who suffered from Hepatitis A was observed to be zero and candidates who suffered from Salmonella in group C was observed to be 1 and 29 candidates did not fall ill due to Salmonella.

Table 3 shows results obtained from the candidates participated in the survey and consumed the processed water for a period of three months to determine the effectiveness of the process of purification of industrial effluent on the occurrence of water borne diseases. Thus based on the data collected by the survey conducted on 90 candidates residing in the nearby locality of the manufacturing unit and consuming contaminated water for a period of 6 months. During the period of 6 months because of consumption of contaminated water many of the candidates suffered from water borne diseases. To reduce the occurrence of water borne disease survey was conducted on the efficacy of the industrial effluent that was treated by aerobic treatment, ion exchange treatment, and anaerobic treatment and it is observed that after consuming the treated water for a period of 3 months most of the survey candidates showed reduced symptoms of water borne diseases.

Table 3: Shows the results obtained from the candidates participated in the survey and consumed the processed water for a period of three months to determine the effectiveness of the process of purification of industrial effluent on the occurrence of water borne diseases.

Patient group 30 candidates each	Candidates who suffered from Typhoid fever	Candidates who suffered from Cholera	Candidates who suffered from Giardia	Candidates who suffered from Dysentery	Candidates who suffered from Escherichia Coli (E.coli)	Candidates who suffered from Hepatitis A	Candidates who suffered from Salmonella
Group A (30 candidates)	-	-	1	1	-	-	-
Group B (30 candidates)	1	-	2	1	-	1	-
Group C (30 candidates)	-	1	-	-	1	-	1

CONCLUSION

Usually the manufacturing unit produce the industrial waste to flow in the nearby water stream which results in the pollution of the water stream and also results in serious health issues to the group of people residing in the nearby locality. Industrial waste is the by-product of different manufacturing units including automobiles, electronic gadgets, clothing, footwear, processed food, beverages, and many more. To facilitate the process of drilling, a high quantity of water having a high concentration of magnesium, barium, manganese, chloride, sodium, iron, strontium, methanol, sulphate and other industrial substrates dissolved in water including a high concentration of chemicals is released. Water treatment plants: the industrial effluent produced by the plants set up to treat the waste water includes hazardous components that are mixed with the water.

The treatment of water having hazardous components mixed in it is difficult to purify even by treating through chlorine and may contains residues of haloacetic acids, trihalomethanes dissolved in water. The solid effluent of industry contains organic synthetic compounds usually released from every household, common solids, heavy metals, and bio-solids. Mining and Extraction Industry: the mine tailing is the industrial effluent released after the finely grounded rock is separated after performing the mining operations of the mineral

concentrate including silver and gold are removed. Efficiently handling the mine tailing is the responsibility of the every manufacturer dealing with mining and extraction.

Thus, to remove the impurity present in the industrial effluents and to provide the population residing in the nearby area of the manufacturing unit a survey is conducted to determine the efficiency of the process followed to remove the contamination from the industrial effluent. Thus, based on the data collected by the survey conducted on 90 candidates living in the nearby area of the manufacturing unit and drinking contaminated water for a period of 6 months. In the period of 6 months prior to survey, due to consumption of contaminated water many of the survey candidates suffered from water borne diseases. To reduce the occurrence of water borne disease and to maintain the wellbeing of the population residing near the manufacturing unit, a survey was conducted on the efficacy of the industrial effluent that was treated by aerobic treatment, ion exchange treatment, and anaerobic treatment and it is observed that after drinking the aerobically, anaerobically and ion exchange treated water for a period of 3 months most of the survey candidates showed reduced symptoms of water borne diseases. Thus, current study opens a future prospects to conduct more research on the efficiency of the process used to treat the industrial effluent in order to provide a contamination free water and thus save the environment from pollution.

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