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A Study on the Waste Water Treatment Technology for Steel Industry: Recycle And Reuse.

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Abstract: - The steel industry is one of the most important and vital Industry of the present and the future. It is the asset of a nation. Steel plants use a tremendous amount of water for waste transfer, cooling and dust control. The steel plants have sintering mills, coke plants, blast furnaces, chemical byproducts and chemical processes, water cooled rolls, pumps, extrusion experiment, transfer lines for sludges and slurries. All these plants use a tremendous amount of water to cool the products and flush the impurities away from the finished stock.

Wastewater is generated in huge quantity in steel industries. It contains many dissolved, undisclosed substances and chemicals in the wastewater. The steel industries produce wastewater and sludge during different industrial processes.

The development of innovative technologies for treatment of wastewaters from steel industries is a matter of alarming concern for us. Although many research papers have been reported on wastewater pollution control studies, but a very few research work is carried out for treatment of wastewater of steel industries, especially in reference to development of design of industrial effluent Treatment Plants (ETP) system. Another beneficial aspect of this research work will be recycling, reuse of water and sludge from steel industry

The whole technologies for treating industrial wastewater can be divided into four categories: - Chemical, Physical, Biological and mathematical approaches. Physical treatment methods include sedimentation, Floatation , filtering , stripping, ion – exchange, adsorption and other processes that accomplish removal of dissolved and undisclosed substances without necessarily changing their chemical structure. The mathematical approaches are very useful and more realistic for developing a well operating cost–effective treatment system for industrial wastewater treatment.

I. INTRODUCTION

The steel industry is one of the most important and vital Industry of the present and the future. It is the asset of a nation. Steel plants use a tremendous amount of water for waste transfer, cooling and dust control. The steel plants have sintering mills, coke plants, blast furnaces, chemical byproducts and chemical processes, water cooled rolls, pumps, extrusion experiment, transfer lines for sludges and slurries. All these plants use a tremendous amount of water to cool the products and flush the impurities away from the finished stock.

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The treatment of steel industrial wastewater requires a variety of strategies to remove different types of contaminants. These are:
1. Solid removal
2. Oil and Grease removal
3. Removal of biodegradable organics.
4. Activated sludge process
5. Trickling filter process
6. Treatment of toxic materials
7. Treatment of acid & alkalis
8. Treatment of other organics.

Technologies used in steel plants include cooling Tower, DM Plant, STP and river water treatment. The wastewater Treatment Plant (WWTP or STP) possesses conventional methods like primary Treatment, Secondary treatment and Tertiary treatment followed by ozonation method. In the last, River water treatment was done which contains chlorination, preozonation, Flocculation, Filtration / aeration, pH correction, Adsorption processes etc.

In the present study, the research work will be undertaken for characteristics of wastewater of steel industry, innovations in technology for wastewater treatment of steel industries and recycling and reuse of water and sludge of steel industries. Emphasis will be given on filtration, chlorination and adsorption technology in the light of mechanistic view for the steel industrial wastewater treatment.

A design of industrial wastewater treatment plant for steel industry will be undertaken. This technology will be very useful and efficient for the treatment of industrial effluents. It will be very fruitful for the development of sustainable environment. Water reuse and recycling of sludge is another beneficial aspect of this study. A proper plan for the reuse of water for various purposes and utilization of sludge for making (producing) different industrial byproducts will be given.

Recycling of wastewater is a mechanical process, which includes purification of wastewater upto the standard in a separate lagoon and internal circulation to the system for its water requirement.

Reuse of water implies following three important uses:-
(i) Cooling and processing water in industrial applications.
(ii) Irrigation for cropland, golf courses, water requirement for plant and grass growth.
(iii) Ground water recharge: reused water can be directly injected into aquifers or applied to land for percolation into the aquifer.

Reuse and recycling of water will inevitably be the essential strategies for protection and conservation of water resources, which are getting scarce and polluted day by day.

II. STATEMENT OF THE PROBLEM

A study on wastewater treatment technologies is very significant facet of water pollution studies. Different types of research works are carried out on water pollution studies, but a very few research is carried out on development of wastewater treatment technology in reference to steel industries. Such research works are very challenging for Research & Development.

III. REVIEW OF LITERATURE

Many research papers have been reported on waste water pollution studies and removal [1 – 8] but fewer papers are published on wastewater treatment in reference to steel industries using different technologies for control of different pollutants. Some research articles are contributed by the authors [9 – 13] on planning, control and protection from environmental pollution. A very few research papers are available on recycling and reuse of water and sludge [14 – 19]. The use quantitative analysis is much more effective in aspects of wastewater treatment [20 – 22]. Recently, more research attentions have been paid to develop the mathematical model for the biological treatment of industrial wastewater [23 – 25].

Objectives of the Study

The present study has following objectives:-
(I) Characterization of steel industrial effluent.
(II) Design of wastewater treatment system.
(III) Different types of treatment in different tanks.
(IV) Analysis of wastewater after treatment and generation of data.
(V) Quantitative analysis of generated data for cost effective treatment.
(VI) Recycling of wastewater of steel industries.
(VII) Reuse of wastewater and sludge in different industrial processes.

(VIII) Treatment objectives are needed to complete the development of design criteria for handling and treatment equipments.

IV. SIGNIFICANCE OF THE RESEARCH

This research work is very innovative and useful for steel industry. Wastewater is released from different units in Steel industry; need to be managed by treatment processes. Treatment of wastewater by different methods in designed tanks will produce clean and treated water, which will be utilized in different processes in steel industries. Treated wastewater may be used for agriculture, recreational activities and other purposes. A proper design of Industrial Effluent Treatment Plant (ETP) for treatment of wastewater from steel industry is very useful and innovative research work. It will add a momentum to industrial Research & Development (R & D). The reuse of sludge for making different products is another beneficial aspect of this research work.

Hypotheses of the Study

As per the direction of Central Pollution Control Board (CPCB), New Delhi and pollution control statutory bodies, there is a high demand to establish Effluent Treatment Plant (ETP) or Waste Water Treatment Plants (WWTP) in each industry So, there is an urgent need for innovations in wastewater Treatment research or Industrial Effluent Treatment research.

It is essential to develop such a wastewater treatment Plant which is efficient and cost –effective. We will develop a design of efficient wastewater Treatment System which will be fruitful for treatment of wastewater coming from steel industry. A plan for recycling and reuse of water is given. The sludge is used for making different products.

Research Methodology

The standard methodology is followed for analysis of different water quality parameters, pH of sample is measured by pH - meter, temperature is measured by thermometer, turbidity by nephalometer, conductivity is measured by conductivity meter. Other parameters like D.O., B.O.D., C.O.D., chloride, sulphate, total dissolved solids (T.D.S.) are measured by water sampling kit. Optimization techniques and differential equations for quantitative analysis of waste water pollutants may be used to minimize the bacterial growth & effect. We present a small example from the field of bacterial growth and decay as:

To describe the growth of a single organism on a single substrate in a batch reactor with no other growth limitations, we formulate a simple model,

$$\frac{dX}{dt} = \mu(S)X - bX$$

$$\frac{dS}{dt} = -\frac{1}{Y}\mu(S)X$$

Where, X = Concentration of microorganism (mg/l)

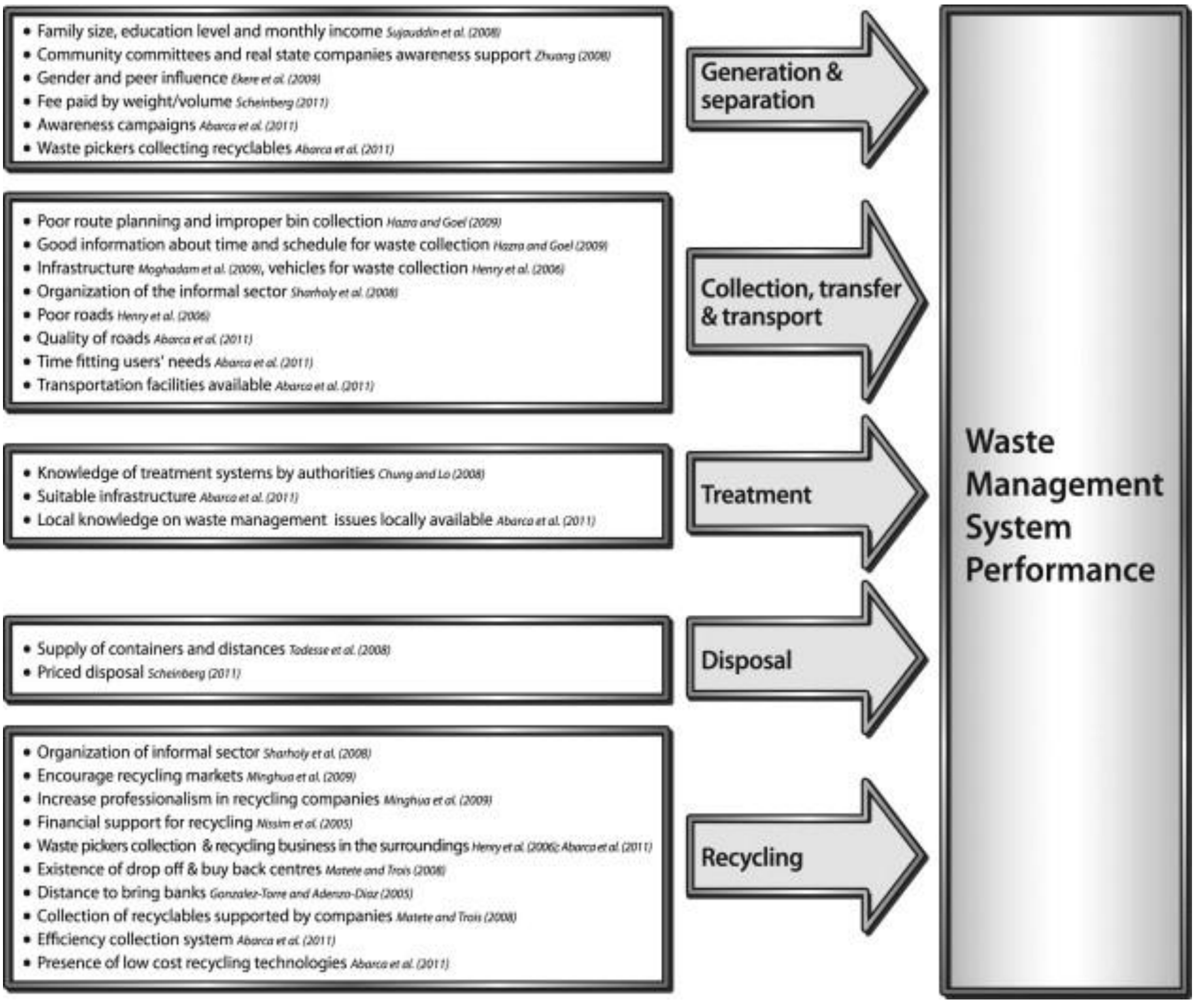
S = Concentration of growth – limiting substrate (mg/l)

μ (S) = Specific growth rate (per day)

b = Decay rate (per day)

Y = Yield factor (g cell COD formed / g COD oxidized)

Then we solve and simulate the model using numerical methods and MATLAB and discuss the stability of the system.



Biological treatment is an important and integral part of any wastewater treatment plant that treats wastewater from either municipality or industry having soluble organic impurities or a mix of the two types of wastewater sources. The obvious economic advantage, both in terms of capital investment and operating costs, of biological treatment over other treatment processes like chemical oxidation; thermal oxidation etc. has cemented its place in any integrated wastewater treatment plant. Biological treatment using aerobic activated sludge process has been in practice for well over a century. Increasing pressure to meet more stringent discharge standards or not being allowed to discharge treated effluent has led to implementation of a variety of advanced biological treatment processes in recent years. The title of this article being very general, it is not possible by any means to cover all the biological treatment processes. It is recommended that interested readers, for deeper reading and understanding, refer to well-known reference books e.g. Wastewater Engineering by Metcalf & Eddy etc. This article briefly discusses the differences between aerobic and anaerobic biological treatment processes and subsequently focuses on select aerobic biological treatment processes/technologies. Biological Wastewater Treatment This article briefly discusses the differences between aerobic and anaerobic biological treatment processes and subsequently focuses on select aerobic biological treatment processes/ technologies. By Arun Mittal Aerobic & Anaerobic Before we go in to the discussions of various aerobic biological treatment processes, it is important to briefly discuss the terms aerobic and anaerobic. Aerobic, as the title suggests, means in the presence of air (oxygen); while anaerobic means in the absence of air (oxygen). These two terms are directly related to the type of bacteria or microorganisms that are involved in the degradation of organic impurities in a given wastewater and the operating conditions of the bioreactor. Therefore, aerobic treatment processes take place in the presence of air and utilize those microorganisms (also called aerobes), which use molecular/free oxygen to assimilate organic impurities i.e. convert them in to carbon dioxide, water and biomass. The anaerobic treatment processes, on other hand take place in the absence of air (and thus molecular/free oxygen) by those microorganisms (also called anaerobes) which do not require air (molecular/ free oxygen) to assimilate organic impurities.

The final products of organic assimilation in anaerobic treatment are methane and carbon dioxide gas and biomass. The pictures in Fig. 1 and 2 depict simplified principles of the two processes.

Table I summarizes the major differences in these two types of processes. From the summary in Table 1, it can be concludedthat it is not anaerobic or aerobic treatment, but a combination of the two types of the technologies that give an optimum configuration for those wastewater treatment applications where the organic impurities are at a relatively higher concentrationIntegrated Fixed Film Activated Sludge (IFAS) System: There are several industrial installations where two stage biological treatment comprising stone or plastic media trickling filter (also known as packed bed biotower) followed by activated sludge process based aeration tank, followed by secondary clarifier have been in operation. Another modification of above configuration that has been implemented in newer industrial wastewater treatment systems is fluidized media bioreactor (also known as moving bed bioreactor (MBBR)) in lieu of biotower followed by activated sludge process. In some of the industries (e.g. refineries and petrochemical plants, where the existing wastewater treatment system was single stage conventional activated sludge process (based on aeration tank and clarifier unit), that underwent capacity expansion and/or faced stricter discharge regulations, the up-gradation of activated sludge process by addition of fluidized bio-media has been implemented to meet these requirements.This hybrid process of fluidized media and activated sludge process taking place in a single aeration tank is known as Integrated Fixed Film Activated Sludge (IFAS) process. The common advantages of all of the above described configurations are as follows:

- Fixed film media provides additional surface area for biofilm to grow on it and degrade the organic impurities that are resistant to biodegradation or may even be toxic to some extent.
- The overall efficiency of two stage biotreatment system is better than activated sludge process alone.
- Fixed film processes are more effective in nitrification of the wastewater than activated sludge process.
- The overall foot-print for a fixed film process based system is smaller than the activated sludge process system.
- Due to less sludge wastage, the sludge handling and dewatering facility is smaller compared to the activated sludge process. Comparing IFAS with other configurations i.e. biotower followed by activated sludge or MBBR followed by activated sludge, following advantages for IFAS can be highlighted:
- It can be easily incorporated in the existing activated sludge system to meet additional processing capacity requirement and/or stricter discharge regulations without the need of additional concrete tanks.
- Foot-print of IFAS is smaller.
- Capital and operating cost for IFAS is lower.

Membrane Bioreactor (MBR): Membrane Bioreactor (MBR) is the latest technology for biological degradation of soluble organic impurities. MBR technology has been in extensive usage for treatment of domestic sewage, but for industrial waste treatment applications, its use has been somewhat limited or selective. The MBR process is very similar to the conventional activated sludge process, in that both have mixed liquor solids in suspension in an aeration tank. The difference in the two processes lies in the method of separation of bio-solids. In the MBR process, the bio-solids are separated by means of a polymeric membrane based on microfiltration or ultrafiltration unit, as against the gravity settling process in the secondary clarifier in conventional activated sludge process. Therefore, the advantages of MBR system over conventional activated sludge system are obvious as listed below:

- Membrane filtration provides a positive barrier to suspended bio-solids that they cannot escape the system unlike gravity settling in activated sludge process, where the bio-solids continuously escape the system along with Treated Effluent clarified effluent and sometimes a total loss of solids is also encountered due to process upsets causing sludge-bulking in the clarifier. As a result, the bio-solids concentration measured as MLSS/MLVSS can be maintained at 3 to 4 times in an MBR process (~ 10,000 mg/l) in comparison to the activated sludge process (~2500 mg/l).
- Due to the above aspect of MBR, aeration tank size in the MBR system can be one-third to one-fourth the size of the aeration tank in an activated sludge system. Further, instead of gravity settling based clarifier, a much more compact tank is needed to house the membrane cassettes in case of submerged MBR and skid mounted membrane modules in case of non-submerged, external MBR system.
- Thus, MBR system requires only 40-60% of the space required for activated sludge system, therefore significantly reducing the concrete work and overall foot-print.
- Due to membrane filtration (micro/ultrafiltration), the treated effluent quality in case of MBR system is far superior compared to conventional activated sludge, so the treated effluent can be directly reused as cooling tower make-up or for gardening etc. Typical treated water quality from MBR system is:
- BOD5< 5 mg/L
- Turbidity < 0.2 NTU An external, non-submerged type MBR for industrial applications especially in refineries and petrochemical wastewater applications, is the Aqua-EMBR (Aquatech's Enhanced Membrane Bioreactor). Aqua-EMBR has been successfully piloted to treat wastewater from a petrochemical plant in middle-East. Aqua-EMBR filtrate was further processed through High Efficiency Reverse Osmosis (HEROTM) process to

recover 90% high quality permeate. The permeate quality was suitable for its recycle as feed to the demineralizer system.
The advantages of Aqua-EMBR over submerged MBR systems include:
• Aqua-EMBR system (membrane modules) has no membrane tank, it can be built much quicker with less risks for contractors:Installed as skid(s) on a flat concrete slab, no complex civil works required.Civil works and skid assembly are independent and parallel activities.
Less risk for contractors because of delays in civil works due to weather conditions, environmental or other local uncertainties.
• The system offers an operator friendly working environment as opposed to obnoxious environment in case of submerged systems:Operators don't see, smell or come in contact with the biosludge. Operators do not work on top of open membrane tanks where the air could contain harmful aerosols. In case of any maintenance issue, the membrane modules in Aqua-EMBR can be removed or replaced without any contact with the biosludge, whereas submerged membrane modules contaminated with sludge, have to be lifted out of tanks posing potential contact with the sludge.
• The flux is ~50% higher which equates to 50% less surface area of membrane needed per unit volume permeate production. This results in: Lowest membrane cost per unit volume filtrate, resulting in lower capital and operating costs. Smallest footprint (about 20% less). Lowest maintenance costs (chemicals, man-hours etc.).
• Electrical power consumption is 10 to 15% lower compared to submerged systems due to the use of airlift pump effect.
• Aqua-EMBR has the tightest membrane pore size: Pore size nominal / maximum: 30 nm / 50 nm Turbidity of permeate: < 0.2 NTU TSS levels: < 0.5 mg/l
Highest effluent quality is an important factor for re-use purposes and future regulations
Comparison Of Aerobic Biological Treatment Options
A detailed technical evaluation of various options of biological treatment processes for a given wastewater from a refinery and the treated effluent quality requirements has been carried out. Based on this evaluation, Table 2 summarizes the pros and cons of each option.
Based on these comparisons, it can be inferred that CASSTM technology is superior to other aerobic biological treatment technologies in terms of overall life cycle cost and returns to the owner.

Objectives of the Study
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