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Sustainable Mini ETP for Small Industries: A Case Study of Powder Coating Industry

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Abstract*: Effluent Treatment Plants (ETPs) are considered as one of the viable solution for small to medium enterprises for effective wastewater treatment. An Effluent Treatment Plant (ETP) is an integral part of production processes with relevance to wastewater, the pollutants with their respective limit values that have to be reduced. In addition, the ETP also facilitates in reduction of number of discharge points in an industrial estate for better enforcement by environmental regulatory agencies in terms of pollution reduction and environmental improvements. However, many of the operating ETPs are not performing optimally due to various technical and managerial reasons. Small scale industries usually do not have access to latest technological advancements in effluent treatment process. To address the pollution discharge of industries, adoption of cleaner production technologies and waste minimization initiatives are now gaining ground. Treatment of such industrial effluent is very important and necessary from environmental point of view. Also, to meet the Standards for emission or discharge of environmental pollutants from various Industries set by the Government and to avoid hefty penalties ETP is a need for the industries. In present case study an attempt is made to design a compact but sustainable mini effluent treatment plant for small scale industry i.e. powder coating unit. This mini ETP requires smaller space as compared to traditional ETP with old technology. By using such compact modular mini ETP for small scale industry issue of non-treating or partly treating effluent can be overcome with cost and space efficiency. This will enable small scale industries to cater their need to avoid pollution and also to safeguard environment.

Keywords: Effluent Treatment Plant, Pollution, Small Scale Industry

I. INTRODUCTION

In any industry effluent is generated during the process of manufacturing. The process of industrialization is adversely impacting the environment globally. Pollution generated by incorrect management of industrial wastewater is one of the major environmental problems in India as well, especially with burgeoning small scale industrial sector in the country. ETP (Effluent Treatment Plant) is a process design for treating the industrial waste water for its reuse or safe disposal to the environment. Most important point to note is to safeguard environment against pollution and contribute in sustainable development. Large scale industries can set up state of the art effluent treatment plan (ETP), as per requirement of their product and manufacturing process and also type and quantum of effluent generated during production process. Industrial wastewater treatment describes the processes used for treating wastewater that is produced by industries as an undesirable by-product. The treated industrial wastewater (or effluent) may be reused or released to surface water in the environment, after satisfying outlet norms. Large scale or big industries can avail the latest technology available for treatment of effluent generated at their plant. They are having sufficient space for construction of ETP, as per the requirement of treatment and also the norms of the pollution control bodies. Also, they can afford the bigger capital investment, advanced technology for construction of ETP and expert / skilled manpower required for operation and maintenance of ETP.

On the other hand, for small scale industries it is very difficult to have enough space required for construction of a separate ETP for their own use. Also, there are some limitations which need to be considered, such as insufficient funds for setting up a separate ETP, the quantity of effluent generated may be small and separate ETP for such smaller quantities may not economically viable and technology required for construction and operation of ETP. In addition to the above, for small scale industries it is difficult and not affordable to deploy the skilled manpower required for operation and maintenance of such small capacity ETP.

Considering the above factual limitations and difficulties of small scale industries, it is very much needed to plan, design and develop a feasible, economical and sustainable mini effluent treatment plant for micro and small industries to treat their effluent primarily to make them available solution to their genuine problem and also prevent pollution and safeguard the environment from damage and degradation. This small capacity mini effluent treatment system will help micro and small industries to install the ETP in their premises to tackle the issue of effluent treatment as per requirement of the authority, which is affordable and consuming less space. Also, such small capacity ETP can be operated by the available technical manpower with imparting basic training to them regarding the operation and maintenance of such mini ETP. So that this small ETP can be operated with very less and affordable operating cost, which will make the installation and operation of ETP economically viable and technically feasible to treat the generated effluent at the point of origin so as to prevent pollution and protect the environment.

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II. MATERIAL AND METHODOLOGY

A. Material

Research papers from the studies conducted in the past and Governments norms for prevention / control for pollution are referred and reviewed for literature study to identify the gaps,if any and also to suggest bridging these observed gaps for benefits of the society and environment.

B. Methodology

Methodology involves the review of the studies conductedin the past to understand the issue from different perspectives and to identify the gaps for addressing these gaps by suggesting appropriate measure, developing ETP for small scale industries. Overall methodology is as shown in (Fig.1).

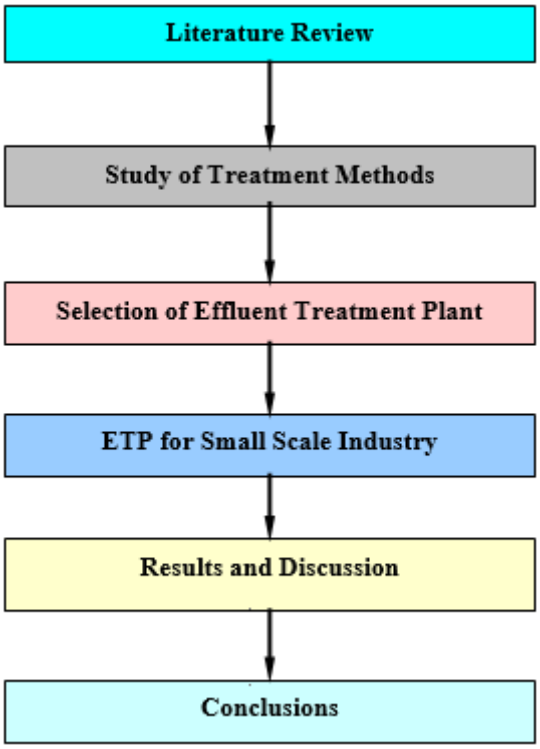

Fig. 1. Methodology Flow Chart

III. LITERATURE REVIEW

As water is becoming a scarce resource, the use of reclaimed water for many purposes is receiving increasing attention. There is a risk to use reclaimed wastewater with respect to potential exposure to microorganisms and hence proper treatment to the wastewater or effluent generated before such use. Advanced wastewater treatment can produce almost any water quality desired and has become more reliable and effective through experience and innovation [1]. With stricter requirements for wastewater treatment, small-scale individual wastewater treatment plants can provide a financially attractive alternative to a sewer connection in locations far from the existing sewer network. However,there are hardly any data on how small-scale individual household wastewater treatment facilities operate. With the environmental requirements being tightened, the design, technological process, and maintenance of these devices must be improved [2]. In this study estimation of various aspects of wastewater was carried out and results highlight the vast potential of treated wastewater as an unconventional water resource for augmenting water resources and alleviating water scarcity, particularly in water-scarce regions [5].

This study has been carried out using indigenously available materials for economics point of view, the results of the tests on different parameters being within the permissible limits according to CPCB are fit to be reused for different applications such as flushing, street cleaning, irrigation and other non-potable uses and also aiding in reduction of load onthe STPs thereby increasing its working efficiency. The easy operation, usage of indigenous materials, less maintenance, less power, low operation and maintenance cost contributes to significant and efficient ways of treating and reusing the wastewater in rural communities and small units. This is alsoproved to be eco-friendly as no toxic chemicals are used in the treatment [6]. Adversely affected water generates wastewater which contains potential hazards such as organic as well as inorganic pollutants which intern have a detrimental effect on the environment and human health. A viable solution to this problem would be to develop better developments in wastewater management systems, whichwould make treated wastewater available for purposes of irrigation, gardening and other industrial purposes. This would directly decrease the load from natural reservoirs thus maintaining the availability of naturally available water; this would even help groundwater to replenish over time. Better methodology for wastewater treatment suggested in this review could provide a solution for developing countries with low economy; the treatment methods are cost-efficient and effective [4]. Wastewater treatment is an important initiative which must be taken more seriously for the betterment of the society and our future. Modelling a ETP is a difficult task and most of the available models are just approximate ones based on, probably severe, assumptions. These features make it difficult to achieve optimum performance of the ETP using conventional modelling techniques [3].

In this study wastewater treatment practices in Indian tanneries were reviewed 64 relevant reports and articles were shortlisted and studied. The results showed that coagulation with alum and ferric chloride gave the best results in primary treatment, aerobic and anaerobic processes gave the best results when combined, and tertiary treated water could be reused [7]. This study was carried out for wastewater treatment by effluent treatment plants. 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 [8]. Effluent from the treatment plants, often, not suitable for household purpose and reuse of the waste water is mostly restricted to agricultural and industrial purposes.

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Wastewater-irrigated fields generate great employment opportunity for female and male agricultural laborer's to cultivate crops, vegetables, flowers, fodders that can be sold in nearby markets or for use by their livestock. However, there are higher risk associated to human health and the environment on use of wastewater especially in developing countries like India [9].

In this study designing a treatment plant was studied, as every sector contributes a particular amount of waste and today due to its unaware disposal environment get affected. The commercial processes tend to generate a lot of waste and require regular maintenance and expensive waste disposal [10]. It is a time to give a pause to the pollution and phase it out gradually to protect the river sys-tem. It had become a prerequisite to set up ETP in each industrial establishment, particularly at dyeing industries that were discharging huge amount of liquid waste to the rivers every day. From this study it is concluded that for the successful implementation of ETPs, industry owners will have to be socially responsible and at the same time, government should provide the factory owners with logistic supports and relaxed timeframe to set up ETPs [11].

IV. EFFLUENT TREATMENT PROCESS AND DESIGN

The category of industry selected for design of effluent treatment plant is of small scale type industry. The activity of the industry is powder coating for auto mobile and engineering components. The manufacturing process flow of the industry is as below.

1. Inspection of components
2. Pre treatment of the components to remove rust, dust and other depositions on the surface of components.
3. Heating of components to remove the moisture from surface of components and make components ready to received powder for coating on the surface.
4. Baking of components in the oven at the temperature of 200 ^{0} C.
5. Unloading of baked components from the oven and inspection of components.
6. Packing and dispatch of good quality components.
7. Draining out the tanks used for pre treatment process for treatment of effluent in ETP.
8. Treatment of effluent in ETP.
9. Reused / disposal of treated effluent as per MPCB's norms.
10. Collection and sending sludge generated during treatment of effluent to hazardous waste management facility.

The effluent generated from the pre treatment process is not on daily bases. Once the required characteristic of the chemical, solutions and rinse water in the pre treatment tanks is not suitable for further treatment on components the solution in the tanks and rinse water is required to change and replace by new solution and water. The drained solution and water is further sent to collection tanks for further treatment in the ETP. As per process flow for powder coating industry average 250 Liters / Day or 1500 Liters / Week effluent is generated, which requires treatment. The process flow of ETP is as below.

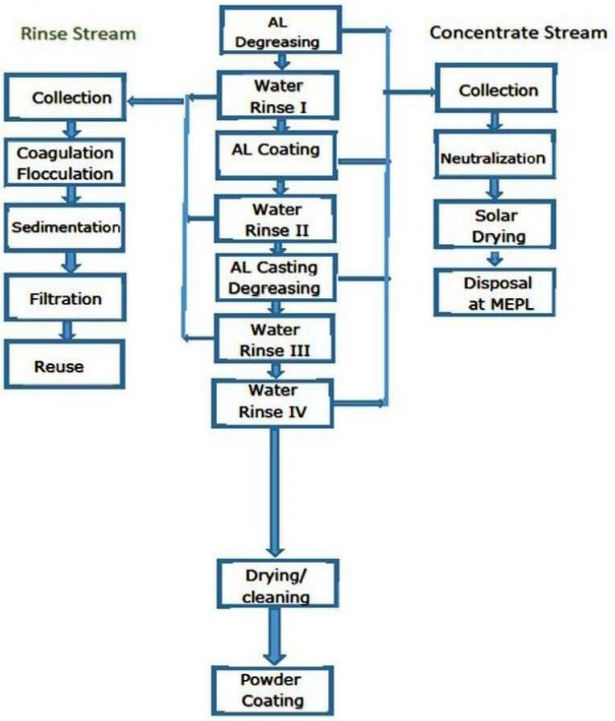

Fig.2. Production Process Flow for Powder Coating Industry

Effluent Treatment Plant is needed

- To clean industry effluent and recycle it for further use.
- To reduce the usage of fresh/potable water in Industries.
- To cut expenditure on water procurement.
- To meet the Standards for emission or discharge of environmental pollutants from various Industries set by the Government and avoid hefty penalties.
- To safeguard environment against pollution and contribute in sustainable development.

Treatment levels and Mechanisms used in ETP are as below

i) Treatment levels:

- Preliminary
- Primary
- Secondary
- Tertiary (or advanced)

ii) Treatment mechanisms:

- Physical
- Chemical
- Biological

V. RESULT AND DISCUSSION

There are various types ETPs with different capacities of treatment of effluent and based on technology suitable for treating the effluent, as needed. For present case study a sustainable Batch type compact modular mini ETP is proposed as shown in (Fig. 3).

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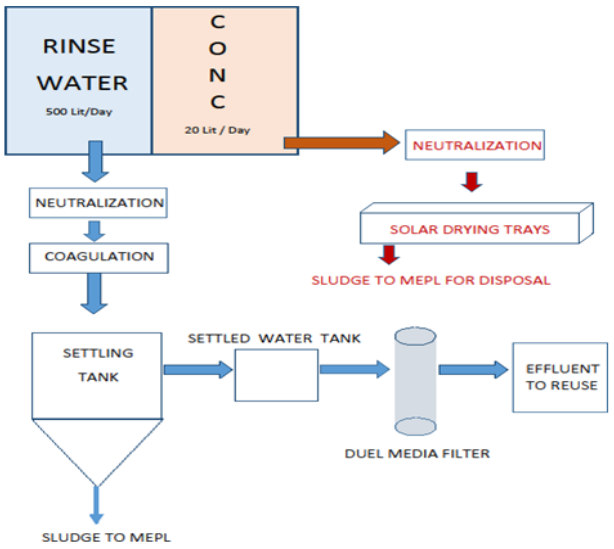

Fig. 3. ETP Process Flow for Powder Coating Industry

The features of proposed mini ETP are described as below.

- Cost effective: Initial investment is less.
- Type: Batch (Compact Modular)
- Functioning: Manual, Semi-Automatic and Fully Automatic, as per requirement.
- Compact and Sturdy Design: It requires very small space to install and it is sound for working.
- Quality Components and Mounting Items: Special sludge pump and total corrosion free UPVC piping & FRP/Epoxy Lined Mild Steel tanks.
- Water Recycle: Recycling of treated is possible with advanced treatment methodology like UF and RO.
- Operation and Maintenance: Silent in operation and any person can operate it, with short time proper training
- Types of Industries where can be used: Metal pre-treatment, chemical and other type of industries.

Operational scheme of this mini ETP is discussed below

1. **Screen chamber:** Remove relatively large solids to avoid abrasion of mechanical equipment's and clogging of hydraulic system.
2. **Collection tank:** The collection tank collects the effluent water from the screening chamber, stores and then pumps it to the equalization tank.
3. **Equalization tank:** The effluents do not have similar concentrations at all the time; the pH will vary time to time. Effluents are stored from 8 to 12 hours in the equalization tank resulting in a homogenous mixing of effluents and helping in neutralization. It eliminates shock loading on the subsequent treatment system. Continuous mixing also eliminates settling of solids within the equalization tank.
4. **Aeration tank:** The water is passed like a thin film over the different arrangements like staircase shape. Dosing of Urea and DAP is done. Water gets direct contact with the air to dissolve the oxygen into water. BOD and COD values of water are reduced up to90%.
5. **Clarifier:** The clarifier collects the biological sludge. The overflowed water is called as treated effluent and disposed out. The outlet water quality is checked to be within the accepted limit as delineated in the norms of the Bureau of Indian standards. Through pipelines, the treated water is disposed into the environment i.e. river water, barren land, etc.
6. **Sludge thickener:** The inlet water consists of 60% water + 40%solids. The effluent is passed through the centrifuge. Due to centrifugal action, the solids and liquids are separated. The sludge thickener reduces the water content in the effluent to 40 % water + 60 % solids. The effluent is then reprocessed and the sludge collected at the bottom.
7. **Drying beds:** Primary and secondary sludge is dried on the drying beds.

Salient Features of Sustainable Mini ETP are as under

- Biological Oxygen Demand (BOD)
- Carbon Oxygen Demand (COD)
- Maintaining pH
- On site assistance by qualified Engineers
- Minimum or zero discharge
- Colorless and odor less treated water
- Highly suitable for inconsistent sewage
- Recycling of wastewater

The benefits available from this mini ETP are as below

Benefits of Compact Effluent Treatment System areas under

- Based on Green Technology Concept
- Minimum Discharge
- Low power consumption
- Sludge removal once in two years
- Pre-Engineered and Pre-Fabricated Plant
- No odour problem
- Negligible Operating Cost

VI. CONCLUSION

Effluent Treatment Plants (ETPs) are considered as one of the viable solution for small to medium enterprises for effective wastewater treatment. An Effluent Treatment Plant (ETP) is an integral part of production processes with relevance to wastewater, the pollutants with their respective limit values that have to be reduced. In addition, the ETP also facilitates in reduction of number of discharge points in an industrial estate for better enforcement by environmental regulatory agencies in terms of pollution reduction and environmental improvements. However, many of the operating ETPs are not performing optimally due to various technical and managerial reasons. Industrial wastewater treatment describes the processes used for treating wastewater that is produced by industries as an undesirable by-product. The treated industrial wastewater (or effluent) may be reused or released to surface water in the environment, after satisfying outlet norms.

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