Zero Water Discharge for Sustainable Development-An Investigation of a Pigment Manufacturing Industry

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***Abstract*—*The pigment industry is one of the most important industries in India. Its biggest impact on the environment is related to primary water consumption and wastewater discharge. Reuse of wastewaters represents an economical and ecological challenge for the chemical sector. In this research, a 3000 m3/month traditional WWTP plant has been investigated and also suggested for installation of tertiary treatment for zero water discharge for a sustainable development. The results showed that the average recycling of water per month were about 80%. The cost excluded for the treatment by the means of electrical energy and by other means; but the recycling of water by removal of effluents with tertiary treatment can save the cost of purchase of fresh water. It is also observed that the environmental safety can be achieved by reducing the acidic contaminated waste water flow to the environment.*

Keywords—Sustainable Development, Pigment Industry, Reuse, Ultra Filtration, Reverse Osmosis.

I. INTRODUCTION

The concept of sustainable development is based on the observation that economy, environment and wellbeing can no longer be separated. The definition of sustainable development is often quoted from the World Commission on Environment and Development (WCED, 1987): 'development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs'. The fundamental principle behind this definition is to accept that all human individuals have equal rights, whether living today or in future [1]. The Brundtland Commission defines sustainable development as a development that fulfils the needs of the present generation, without compromising the ability of the future generations to fulfill their needs [2]. Sustainability implies that the supply of "natural capital" is maintained. The use of renewable sources such as water should not exceed the rate of renewal, the use of nonrenewable resource like fossil fuel should be such that they will not be exhausted before alternative sources are available, and fundamental ecological processes and structures should be maintained [3]. Sustainability means evaluating not only the consequences of choices for the present situation but also taking into account the consequences for the (far) future. De Groot [4] even defines the concept of sustainability exclusively as the long-term aspect. Consciousness of time is at the base of sustainability. Being conscious of time, however, does not bring about knowledge of the needs of future generations. Publications on sustainability differ widely in the way uncertainty in the needs of the future is taken into account (see, for instance, [4, 5, 6, 2]). Sustainability challenges us to reflect on wastewater treatment differently. Instead of focusing on end-of-pipe-treatment for emission prevention, attention shifts towards optimal resource utilization, favoring the development of decentralized systems. Previous LCA studies in the area of water cycle management have mainly addressed specific aspects of wastewater systems, i.e., quantifying environmental loads of wastewater systems [8]. Water is a limited and, in the mean time, the most strategically important resource on Earth, which is essential for urban, industrial and agricultural needs. With the ever-increasing urban population and economic activities, water usage and demand are continuously increasing. Water has a major role in virtually every product that is produced by industry. As discharges of industrial effluents have increased, clean water has become increasingly scarce. Hence, industrialization has accelerated pollution in the water environment, making water a limited resource. Water is used for various applications and its quality changes due to introduction of contaminants. The remediation of industrial wastewaters requires more robust treatment schemes than typical municipal wastewater treatment systems. This is because the characteristics of industrial wastewater treatment plant influents vary from one plant to another depending on the activities and time. Moreover the composition of industrial wastewaters is characterized by diversified high concentrated constituents [7]. Traditional WWTPs have

been designed based on historical design practices which has conservative design guidelines and standards. Procedures
were often passed from one operator to another without considering new approaches which may improve the performance or reduce the costs, but in last few years industries are moving towards sustainability in waste water treatments and reuse of water. Wastewater reclamation and reuse has become an attractive option for protecting the environment and extending available water resources.

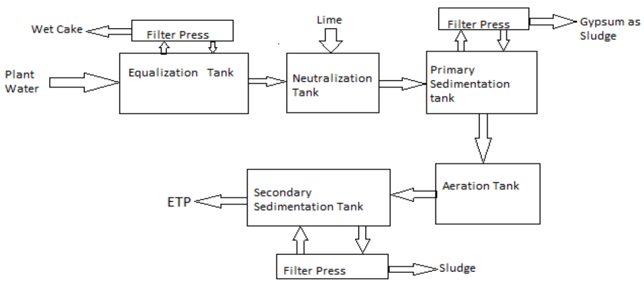

Fig. 1: Existing Water Treatment Plant

In this research the waste water treatment plant of a pigment manufacturing industry is analyzed where the waste water is treated up to secondary treatment as per requirement of government norms and then flowed to the ETP. Figure No.1. shows the schematic diagram of existing WWTP. Here we are presenting the economic and environmental benefits of the zero water discharge process which is possible by installing a tertiary treatment unit next to the existing secondary water treatment unit. The total discharge flow rate of existing water treatment plant is around 3000 m^3 per month. This WWTP consists the following items: Equalization Tank, Neutralization Tank, Primary Sedimentation Tank, Filter Press, Aeration Tank, and Secondary Sedimentation Tank.

System Description

The wastewater generated in the production of pigments was daily characterized over a12-month operating period. The characteristic of influent wastewater is shown in Table 1. Samples were collected throughout the daily operating period and tested in laboratory.

Table.1: Characteristic of influent waste water

Parameter	Unit	Maximum	Average	Minimum
COD	mg/l	1350	870	600
BOD	mg/l	800	380	110
TSS	mg/l	400	210	125
PH	mg/l	3	6	8

The first stage of existing WWTP is equalization tank, having capacity of 1000 m^3. Here all contaminated water is collected from tank and then that collected water is pumped to the filter press where the wet cake of pigments is separated further this water is sent to the second stage i.e. neutralization tank which is having capacity of 40 m^3. At neutralization tank lime is added for reducing the acidic property of water. This neutralized water is pumped to primary clarifier of capacity 600 m^3, where sludge is separated and water is over flooded to the aeration tank. The aeration tank is having capacity of 3000 m^3; at this tank 4 aerators are used for aeration for completing biological treatment. After biological treatment water is pumped to secondary clarifier tank. The capacity of secondary clarifier is 600 m^3, here small sludge is removed and treated water is over flowed to the ETP. Table 2 shows the characteristic of waste water after treatment by existing WWTP.

Table.2: The Characteristic of waste water after treatment

Parameter	Unit	Maximum	Average	Minimum
COD	mg/l	230	195	160
BOD	mg/l	70	65	58
TSS	mg/l	90	83	70
PH	mg/l	6	6.8	7.3

The proposed system is having ultra filtration system followed by reverse osmosis system. This tertiary treatment is designed for the 80% recovery from the water which is being flowed to the ETP.

II. ENERGY ANALYSIS

The advantage of the energy analysis is that the whole comparison is based on a single unambiguously quantifiable indicator, namely energy. Consequently, no weighting of different indicators is involved. Whilst this property makes this analysis straightforward, it is at the same time its limiting factor, as insight is only gained into the efficiency of the processes but not into the different environmental impacts [1].

Here the energy analysis is based on electrical energy used for treatment of waste water. Figure No.2 shows the graphical representation of the energy utilization of existing WWTP for 12-months study period.

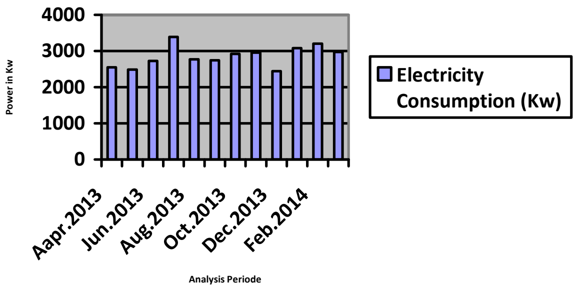

Fig. 2: Energy *Utilization* for 2013-2014

From graph it can be observed that the average amount of energy utilization is 2852.58 Kw. As the proposed system will be added: the electrical energy utilization will increase by around 500Kw. That means the energy consumption will be 3352.58Kw.

III. COST ANALYSIS

The economic theory also suggests a single indicator approach. The central thought behind a sustainability assessment based on economic theory is that sustainability could easily be integrated into decision-making if expressed in terms of money. Tools such as: cost-benefit analysis, life cycle costing, and total cost assessment, all balance the expected costs and benefits, and are often the first step in a project. In theory, all kinds of costs and benefits can be included, however in practice these tools are mostly used as one-dimensional techniques incorporating only financial costs and benefits [1]. The obvious reason is that most social and environmental costs are difficult to quantify. Figure No.3 shows the waste water treatment expenses for 12-months period.

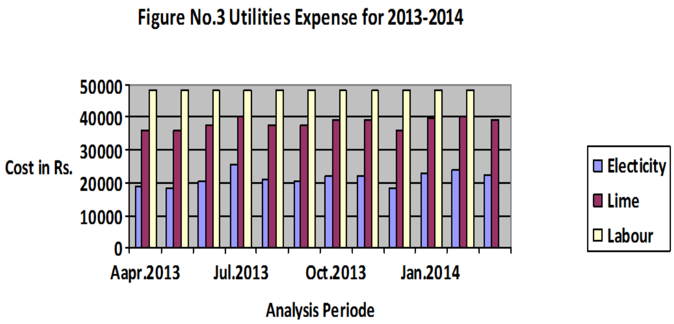

Fig. 3: Utilities Expense for 2013-14

Annual treated water total quantity = 35618 m^3
Average treated water in 2013-2014 = 2968.17 m^3
Water Treatment Costs for 2013-2014:

Table.3: Utilities Expence

Utilities	Total Cost (Rs.)	Average Cost (Rs.)
Electricity	256597.5	21383.125
Lime	457000	38083.33
Labor	576000	48000

Water treatment cost for 1 m^3 of water = (Avg. Electricity Cost + Avg. Lime Cost + Avg. Labor Cost) / (Avg. Quantity of Treated Water)
= (21383.125 + 38083.33 + 48000) / (2968.17)
= Rs. 36.20 / m^3
Rs.36.20 is the cost of waste water treatment for quantity of 1 m^3
The cost calculation for proposed additional treatment is as follows:

1. The zero water unit requires 451.14 kw of energy and 50Kw for other panels for one month therefore,
   Electricity Cost (Rs. 7.50/Unit) = (451.14+50) × 7.50 = Rs. 3758.55
2. Labor Cost :Total working people at existing plant are 6 and only one worker is required for operating the additional system at the cost of Rs.400/day i.e. Rs. 12000/- per month.
3. Maintenance Cost: Rs. 5000/month.

As we calculate above cost for total amount we get a figure of Rs.20758.55/month for additional proposed water treatment system.

Hence, when we calculate the value for treatment cost including proposed system we get an amount of Rs.43.20/ m^3
Which means if we consider the average quantity of water to be treated as same as for year 2013-2014 i.e. 2968.17 m^3, then company will have to spend Rs.1,28,225/month.

IV. COST BENEFIT

The expense for treating waste water by existing treatment plant is compulsory and there is no profit, but as the proposed system is installed; company will save the expense on purchase of water. The proposed system is designed for the 80% recovery of water, which recovers average 2374.5 m^3 of water per month.
This recovery of water saves money on purchase i.e. Rs.78359.69/month.

V. CONCLUSIONS

- By zero liquid discharge minimizing the consumption of freshwater to that of make-up;

therefore, it will help relieve freshwater availability limitations in places where it is scarce or expensive.

- In addition, elimination of liquid discharge will obviate the need to comply with increasingly stringent environmental restrictions.
- Purchased water, and wastewater treatment and disposal costs can be significant; thus, savings associated with minimized site makeup water and wastewater flows can justify capital expenditures to minimize.
- Zero liquid discharge can save money on real estate costs in the case of new facility construction, since location near a suitable receiving waterway would not be necessary.

In addition, zero liquid discharge will help to gain community trust and support and shows sensitivity to the environment.

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