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An appraisal of a waste water treament plant for pulp and paper mill

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Abstract

Due to stringent requirement so fregional regulatory agencies as also about environmental protection, there is a growing concern that is being shown in implementing wastewater management schemes. However, the approach towards solving wastewater management problem is still not that serious as a result, wastewater treatment plants are inadequately designed and constructed. Moreover, after commissioning of treatment plant, there are problems of poor operation and maintenance. All these finally adversely affect the treated wastewater quality, thus, defeating the basic objective of environmental protection. A filed study conducted on one of the pulp and paper manufacturing industry has been presented in the paper alongwith shortcomings and possible remedial measures for achieving improvements.

Key Words:- *Wastewater management, Pulp and Paper mill, Appraisal of Treatment Plant, appropriate strategies, discernible improvement.*

Introduction

One of the water polluting industry is pulp and paper manufacturing industry. To meet the ever increasing demand of paper for various uses, there has been phenomenal growth in pulp and paper manufacturing industry. As a result, large number of pulp and paper making plants have been established. Depending on the raw materials and process technology adopted as also production capacity the paper mills have been grouped in 3 categories namely small,medium and large. While large and medium paper mills use conventional raw materials such as bamboo and wood, the small pulp and paper mills are based on cheaper raw materials like bagasse, waste paper, waste rags etc. These raw materials are the waste products and are relatively economical as compared to bamboo and wood. Moreover use of bagasse and waste paper helps in conservation of forest resources, thereby minimizing the adverse impacts on ecology and biodiversity of the region.

Generally it is seen that there is a tendency in industrial owners to concentrate on production with the sole aim of achieving maximum profits from the investments made while little or no attention is paid to the safe disposal of wastewaters into environment. It is only in recent years that due to stringent regulatory requirements, lot of awareness has been generated amongst the industries and public at large towards environmental protection.

One of the paper mill located in central India was using bagasse and waste paper as a raw material for pulp and paper making and had installed a wastewater treatment plant for the treatment of combined wastewaters. Due to inadequate design and improper operation and maintenance, the treatment plant was not functioning well and as a result the desired standards for treated wastewater could not be met. In the present paper, an attempt has been made to pin-point the descripencies in design and operational problems and inadequacies in the satisfactory performance of the wastewater treatment plant. Possible solutions to remedy these problems have also been deleneated.

Manufacturing Process

The paper mill had an installed capacity to manufacture 30 MT of Kraft paper per day. Unconventional raw materials such as bagasse, wheat straw, waste paper, and hessein bags were being used as main raw material. Bagasse from sugar mills or wheat, straw was used upto 70-80% while the remaining 30-20% was from waste paper, gunny bags or hessein bags.

Bagasse cooking is done in 10% caustic solution in separate digesters rotating at 0.5 RPM. Steam in injected at 170^0C and 100 psi pressure. Digestion is continued for 4-5 hours. Pulping of gunny bags or hessein bags is carried out in separate digesters with 6% caustic solution for a period of 6 hours at 170^0C temperature and 100 psi pressure. The pulp is then passed through sand trap and screens and subjected to washing at 2-3 stages, At this stage, black liquor is drained out. Pulp from waste paper is prepared in hydro-pulper unit and cleaned by passing through sand trap and screen.

In stock preparation section, washed pulps namely rag pulp, waste paper pulp and bagasse pulp are mixed together in a specified proportion and passed on to blending chest. Chemicals are added to it to achieve strength and durability. The pulp is then sent for blending for providing desired pulp to water ratio before sending it to paper machine. The paper machine consists of moving wire mesh and rotary driers. Steam is injected into the driers to remove moisture from the sheet of paper. Finished kraft paper is finally cut to the desired size and it is made ready for marketing. The moisture content of finished paper varies from 2-8% by weight with an average value of 4-5%. Schematic block diagrams for waste paper pulp, bagasse pulp and paper making are depicted in **Figure1.**

Water Consumption

The paper mill used to draw raw water from the nearby perennial river to the tune of 4500 m^3/d. The water received adequate treatment in conventional water treatment plant alongwith ion exchange for removal of dissolved solids before sending it to steam generation plant.For washing of pulp and floor washing and other miscellaneous uses, raw water was directly being used. The break-up of water consumption is as follows:

Process	4000-4500 m^3/d
Water Consumption per MT	130-150^3/MT/d

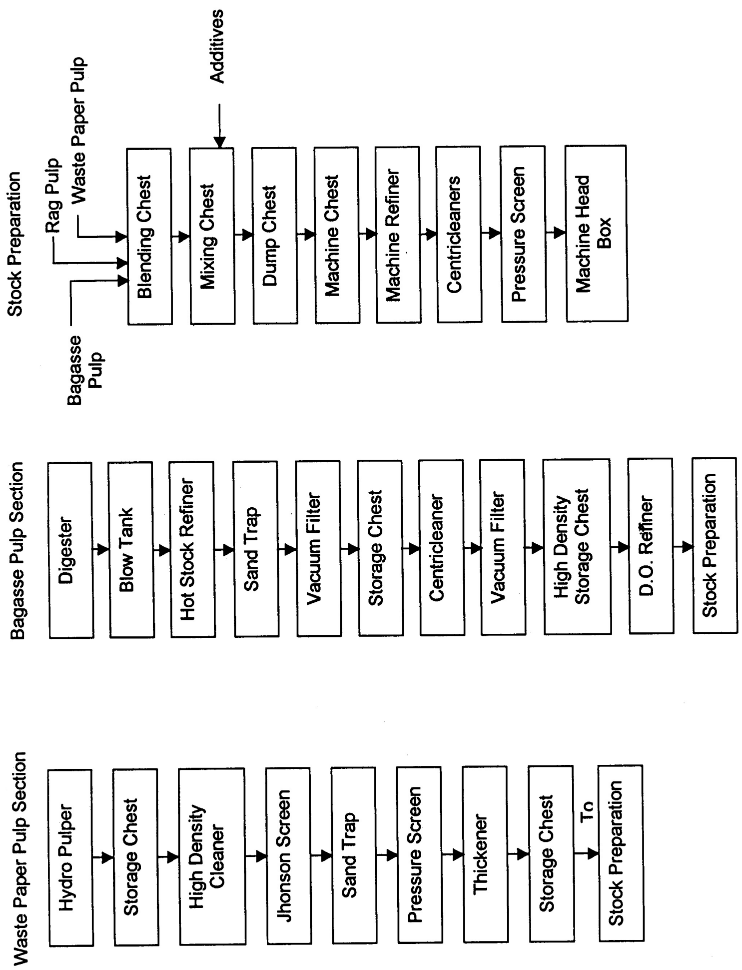

Figure 1: Schematic Block Diagram for Pulp and Paper Manufacture

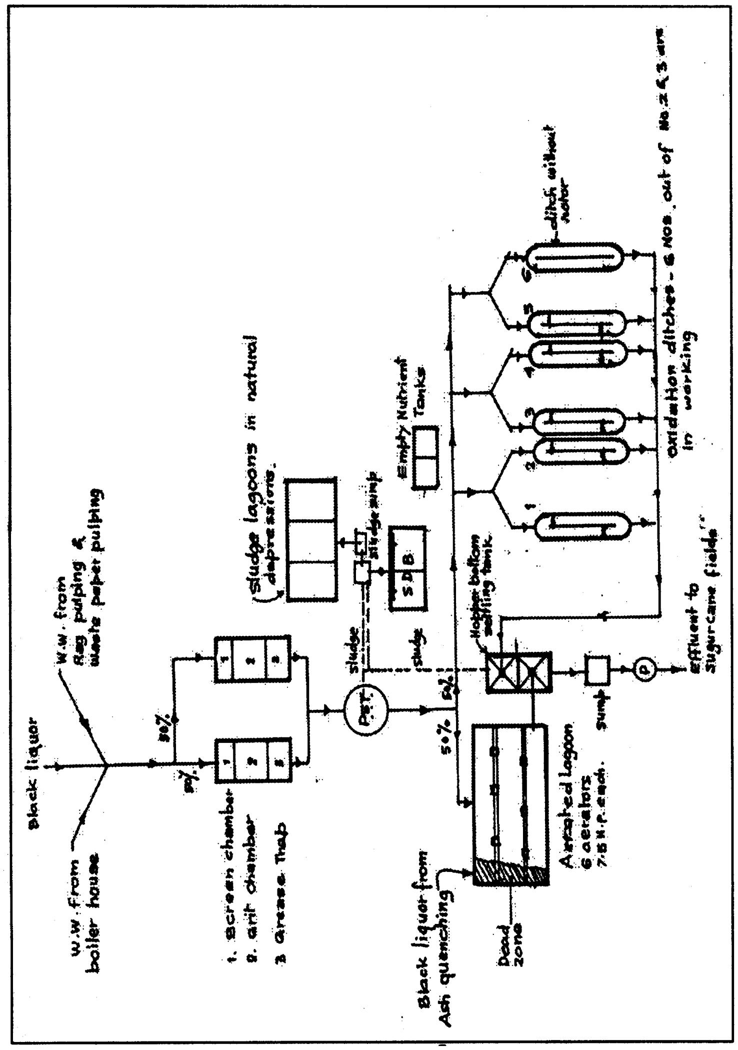

Figure 2: Schematic Flowsheet for the Existing Wastewater Treatment Plant for Pulp & Paper Mill

Wastewater Sources and Quantity

During pulp and paper production, wastewater is emanated from different sources as indicated below:

Black liquor from cooking section
Pulp washing
Boiler blowdown and regenerant water from ion exchangers
Pulp thickener
Paper machine

During the field visit, black liquor drain boiler house drain were separate and wastewaters from other sources was being discharged in a common drain. The wastewater from paper machine was being recycled back for it's reuse. A portion of black liquor was utilized for quenching the burnt hot ash from the boiler.

The wastewater originating from different process sections was between 3000-3600 m^3/d with an average quantity of 3250 m^3/d. Wide variations in waste water quantity were encountered depending on number of process units working at a time. Due to absence of facilities for flow measurements, actual quantities flowing in different drains could not be ascertained. However, the break-up of total wastewater quantity could be obtained and is as follows:-

*Black liquor from 2 bagasse pulp section	1000 m^3/d
*Rag plant section	700 m^3/d
*Boiler blowdown	200 m^3/d
*Waste paper pulp section	650 m^3/d
*Excess wash water from paper machine	500 m^3/d
*Floor washings and misc. wastewater	200 m^3/d
Total Quantity	3250 m^3/d

Existing Wastewater Treatment Facilities

A wastewater treatment plant was provided by the industy and was commissioned at the time of initiation of production. The treatment plant receives combined wastewater and segregation of different wastewater was nonexistent. The wastewater treatment plant comprises the following units:

*Screen

*Grit Chamber

*Grease Trap

Primary Settling Tank
Oxidation Hopper Ditch - 6 Nos
Secondary Setting Tank-2 Nos
*Aerated Lagoon
*Singe Drying Beds-2 Nos
Schematic treatment flowsheet of the WWTP is shown **in Figure2**.

The wastewater treatment plant was designed based on assumed characteristics and kinetic constants for biological treatment units. Design basis of the WWTP was as follows:

Flow	3000 m^3/d
pH	9.5 to 9.8
BOD_5, 20^0C	700 to 800 mg/l
S.S.	1000 to 1200 mg/l

The combined wastewater after treatment in screen, grit chamber and grease trap is passed on to primary setting tank with 3 hours detention time where bulk of the suspended solids settle down and the clear supernatent is led to oxidation ditch and aerated lagoon in equal proportion for biological treatment. The wastewater after oxygenation in both the units is passed on to hopper bottom setting tank of 3.5 hours detention time. The wastewater from secondary settling tank after separation of biological solids is stored in a sump wherefrom it is pumped for utilization on land as a source of irrigation water for sugarcane fields.There is no direct discharge of treated wastewater into near by water body.

Field Observations and Critical Appraisal of WWTP

With a view to plan the strategies for achieving significant improvements in the quality of treated wastewater, a field visit was made for onsite observations on the WWTP wherein each unit of the treatment plant was seen for technical appraisal. The observations made and shortcomings noticed in the WWTP are discussed below.

Screen

*Spacing of screen bars was not uniform as a result of which some of the floating matter was getting passed on to grit chamber.

*Removal of screenings from the screen was not being done at regular intervals.Due to this, heaps of screenings were observed in nearby area.

Grit Chamber

*Grit in huge quanity was seen deposited at the bottom of grit chamber. This had resulted in carry over of gritty material to subsequent treatment units. This had also caused reduction in designed detention time.

Grease Trap

*Foam was observed to be floating over the liquid surface in the grease trap.

Primary Setting Tank

*Due to operation of different pulp sections for meeting the requirements, some of wastewater discharges were intermittent as a result, there were wide fluctuations in the wastewater quantity. In absence of equalization tank, it used to impose shock loads on the treatment plant. In particular the primary settling tank was seen adversely affected as observed from the persistence of suspended solids in the supernatant.

Oxidation Ditch

*There were six units of the oxidation ditch working in parallel. The ditches were constructed in brick masonry. Due to poor workmanship and poor quality construction, masonry walls of 3 ditches got collapsed and bottom of all ditches got severely damaged.

*Out of 6 ditches, only 2were in working condition at the time of field visit. This has resulted in inadequate treatment to the primary treated wastewater.

*Each ditch was provided with 2 horizontal rotors of 3.7 KW (5HP) capacity and out of 10 rotors, only 4 were working.

*The depth of immersion of rotor blades was not uniform in case of rotors in working condition and it was on higher side as compared to desirable value of 16 cm for proper oxygenation to take place.

*2 RCC tanks were seen provided for nutrient (N & P) storage, mixing and addition but these were completely empty with the result that the biological treatment units did not receive nutrient dozing even it is required.

*Arrangement for recirculation of sludge was non-existent. As a result, desired MLSS concentration could not be maintained in the mixed liquor. This had also disturbed the organic loading to the ditch resulting in poor treatment efficiency.

Appraisal of the design of oxidation ditch indicated F/M=0.1, MLSS=5000 mg/l, oxygen requirement= 2 kg of O_2 per kg BOD applied and HRT=26 Hrs. Out of these parameters, MLSS concentration of 5000 mg/l appeared to be on much higher side, particularly in view of the absence of sludge recirculation facility. Spot testing of mixed liquor from one of the ditch indicate MLSS concentration of 2700 mg/l which not only disturbed the organic loading but also resulted into poor treatment efficiency and poor quality of treated effluent.

Aerated Lagoon

*Aerated lagoon of size 60mx50mx3.5m+1m freeboard was constructed in earthwork with sloping sides.

*The lagoon was designed on the basis of arbitrarily chosen value of the system rate constant as 0.234 per day and a detention time of 4 days was provided.

*For oxygenation of the contents of lagoon, 6 aerators of 7.5 HP each were provided. The alignment and spacing of the aerators was not proper since the adjacent aerators were moving in the same direction with depth of immersion varying between 10 to 40 cm. Due to this, even after operating all the aerators, desired oxygenation was not taking place as could be seen from D.O. value between 1.2-1.5 mg/l. At the corners of the lagoon, dead pockets had formed due to insufficient oxygenation. Moreover, depth of lagoon itself being 3.5m was causing low D.O. in bottom layers.

*The black liquor used for quenching the hot ash from boiler was seen getting percolated from the sides and bottom of lagoon due to non-provision of impermeable lining on the sides and bottom of the lagoon which was adversely affecting the functioning of the unit.

Secondary Setting Tank

*2 units of the SST in the form of hopper bottom setting tank with size of each as 12mx 6mx 3m were provided. The oxygenated wastewater from aerated lagoon and oxidation ditch was getting treated in the tank.

*Lot of scum was seen floating over the liquid suface of SST and disludging was not done at regular intervals resulting into sludge deposition within the tank itself and consequently there was reduction in designed detention time.

*The oxidation ditch was designed for 5000 mg/l MLSS concentration while in the aerated lagoon, MLSS concentration in the range of 300-500 mg/l was observed. With these concentrations, the effective MLSS of the combined oxygenated wastewater works out to 2700 mg/l. With such MLSS, for effective removal of S.S. to take place, the SST should have been designed based on solids loading rate with an average value of 4.5 kg MLSS/m^2/d. Instead, the SST was desinged based on the assumed value of surface overflow rate as 20 m^3/m^2/d. This was certainly affecting the treatment efficiency of SST.

Sludge Drying Beds

*At the WWTP, 2 sludge dryingbeds of size 25mx8m were provided. With the sludge from PST with 5% solids content and biological sludge from SST with 1% solids content, the area of sludge drying beds(400 m^2) was inadequate for effective drying and the removal of sludge in semi-solid state once a week was being practiced.

*The design of drying beds based on 5 days drying period and 60 cm depth of sludge. Both these value were inadequate since for effective drying, a dry cycle period of 10 days and a depth of sludge of 30 cm is considered. Due to this shortcoming at the design stage itself, the drying of sludge was not proper.

Strategies for Improvements in the Functioning of Wastewater Treatment Plant

In view of the problems in the design, construction and operation of the WWTP as also shortcomings noticed during field visit, there was a need to formulate most appropriate strategies for achieving discernible improvement in the performance of WWPT with the sole objective of meeting the regulatory requirements. Unitwise suggestions/modifications were suggested as mentioned here under.

Screen

*Spacing of screen bars needs to be made uniform by rearranging the bars so as to have a spacing of 100 mm centre to centre.

*The screening needs be stored separately for drying then dispose of by burning or burying in low lying areas.

Grit Chamber

*Removal of settled grit from the grit chamber needs to be done at regular intervals.The grit removed need be disposed off in low lying area.

*For improving functioning of grit chamber, horizontal velocity of flow need be controlled by installing velocity control device such as parshall flume or proportional flow weir at the outlet of chamber.

GreaseTrap

*The floating foam over the liquid surface need to be removed with the help of nylon scoops or by spraying anti-foaming agent on the surface.

Primary Setting Tank (PST)

*In view of variations in the wastewater flow, there is a need to even out variations by providing equalization basing of adequate capacity. This needs to be provided with mixing arrangement (0.02-0.04HP/1000 gallons volume) for preventing solids from settling within the equalization tank itself.

*A pump of suitable capacity (15 HP) needs to be provided for pumping the equalized flow at a constant rate. This will help in improving the performance of subsequent treatment units.

*Desludging from the PST needs to be done at regular intervals. This will aid in the improvement of existing efficiency.

Oxidation Ditch

*The walls and bottom of oxidation ditch (6 Nos) need to be repaired and reconstucted with sturdy construction. To prevent percolation of wastewater, plastering with waterproof cement be provided to all surfaces coming in contact with the liquid.

*It needs to be ensured that all the 6 ditches alongwith their rotors are kept in operation simultaneously for effective treatment. The depth of submergence of rotor blades needs to be kept at uniform depth of 16 cm for achieving proper aeration of the contents.

*The success of the biological treatment of wastewaters depends on maintenance of BOD:N:P ratio as 100:5:1 and if the wastewaters are found deficient in nitrogen or phosphorus, these are required to be supplemented externally in the term of urea for nitrogen and superphosphate for phosphorus.

With a view to maintain the F/M ratio at the designed level, it is necessary to keep MLSS concentration at a particular level with variations in a narrow range.For this, biological sludge from secondary setting tank needs to be recirculated back to oxiation ditch at suitable recirculation ratio. This ratio needs to be adjusted based on experience with the operation of ditch.

Aerated Lagoon

* The aerated lagoon should be provided with impermeable lining on the sides and bottom. This will help in preventing seepage from the lagoon and cosequently protect the underground water resources from pollution.
* The alignment of the aerators should be so selected that the adjacent aerators rotate in opposite direction and the circle of influence of one aerator touches with the other aerator. For proper splashing action and exposure of waste water droplets to atmospheric oxygen, it is necessary that the depth of submergence of the aerator blades be kept at 100-150 mm.
* It is normally seen that aeration of waste water from pulp and paper mills generates foam in the aeration tank which may become air borne and with the favourable wind velocity , it can get spread in nearby locality , thus disturbing the local residents. Foaming during aeration of pulp and paper mill waste water takes place due to presence of lignin. To overcome this problem, antifoaming agents such as ethyl hexanol need be sprayed over the liquid surface. The dose of this chemical can be fixed after gaining experience on its application.
* In order to see as to whether oxygenation is taking place effectively or not, D.O. levels needs be monitored at various depths along the length and breadth of the aeration tank and it needs to be seen that the D.O. in the mixer liquor of the aeration tank is maintained in the range of 1.5-2.0 mg/l.

Sludge drying Beds

* The area of existing sludge drying beds was worked out considering only primary sludge quantity, sludge layer thickness of 50 cm and dry cycle period of 5 days. To take care of secondary biological sludge (with 1% solids concentration), additional 10 beds of size 65 m x 50 m x 1.05 m need be provided. This has been worked out based on sludge layer thickness of 25 cm and dry cycle period of 10 days for effective drying of sludge.
* The sludge cake after drying needs to be removed and disposed of at a identified site free from human habitation and other activities.

Conclusion

For meeting the requirements of regional regulatory agencies , it becomes mandatory for all manufacturing industries to provide a well designed , constructed , operated and maintained wastewater treatment plant. However, provision of treatment plant receives last priority since the industry is more interested in maximizing the economic benefits and minimizing the cost of production which also includes cost to be incurred on environmental protection. The field survey conducted on one of the paper mill revealed that there were descripencies in the design, construction and operation of the waste water treatment plant. With a view to solve these shortcomings , strategies have been formulated and delineated in the paper.