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Economy Through Environmental Audit: An Indian Scenario

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ABSTRACT

This paper reviews the initial attempts being made in India to establish the practice of environmental audit, especially in the industries that cause pollution and argues that the objective of Environmental Audit is to evaluate procedures and practices that could result in systematic contamination, rather than to detect the potential for severe one time catastrophic releases. Includes a case study which demonstrates the variety of problems that can be identified through an environmental audit.

Keywords: Material Audit, Energy Audit, Water Audit, Health & Safety Audit, Environmental Quality Audit, Conservation Potential.

I. INTRODUCTION

Aparadox of modern technological society is that some of our very efforts towards economic prosperity and increased standard of living could be detrimental to the overall quality of life due to encroachment upon nature beyond its sustenance level or rejection of pollutants to the environment exceeding its assimilative capability. Unless utmost consideration is given to the environmental aspects in our industrial development, we may end up with irreparable damage to the environment. On the other hand, it is also to be recognised that on an issue like environmental sanctity which carried strong social concern and emotional appeal, it is easy to lose scientific objectivity and become rhetoric. For a developing country like India, lack of industrial development and consequent unmitigated poverty could also cause damage to the environment. If we have to guard our environment without seriously blocking the technological development, we need to have a thorough understanding of the environmental processes and their dynamics; we need to develop/ adopt environmentally benign strategies and technologies. Recognizing this need, Ministry of Environment and Forests (MEF) has made "Environmental Audit" compulsory for all industries which require authorisation under the air, water and environment protection acts in each financial year beginning April 1992, to submit an Environmental Audit report to the concerned State Pollution Control Board. By an amendment (vide MEF modification No. GSR 386 (E) dated 22 April 1993), the term for the document has been revised from "Environmental Audit Report" to "Environmental Statement".

In the context of safeguarding the environment, probably no other issue has drawn so much of attention as Environmental Audit. Scientifically speaking, the concern should be whether Environmental Audit Concept has alerted the industries to any significant degree. This calls for an integrated perspective; of an Environmental Audit comprising material, process, fuel, energy, water, health & safety and environmental quality audits.

The emergence of the concept of "SUSTAINABLE DEVELOPMENT" in recent years warrants the implementation of preventive environmental management measures like Environmental Audit (EA) which is an instrument for resource conserving mode in an industrial sector.

EA may be defined as a pragmatic management tool comprising a systematic, periodic and objective evaluation of how well environmental organisation,

management and equipment are performing with the aim of helping to regulate the environment by:

- **a.** Facilitating management control of environmental practices
- **b.** Assessing compliance with industry policies, which would include meeting regulatory requirements

Precisely, Environmental Audit is a technical process of detecting wasteful use of resources and environmental damage that can be avoided in any productive activity. Environmental Audit may not be a totally new concept, but it is certainly a brand new practice in India. The objectives of Environmental Audit comprise minimisation of waste, reduction in consumption of fuel and materials, and improvement in environmental conditions.

A key to success of any Environmental Audit programme is management commitment and support. A case study presented is endorsed by the management and viewed by the line personnel -as a variable tool to ensure that their operations are functioning in accordance with the environmental regulations. The case history identifies not only those areas where non compliance with regulations exists, but also those areas where the potential exists for future problems to be created. Thus the Environmental Audit becomes a tool for planning and management rather than merely a check on how an industry is doing today. To achieve the audit goals, the program has been designed to operate in an atmosphere of co-operation and openness between the industry personnel and the environmental audit team.

II. PROJECT SETTING

The principal raw material for the manufacture of the rayon grade wood pulp is wood, mostly in the form of Eucalyptus (Blue Gum).

In pulp plant, hard wood is washed with water and chipped off in chipper which is screened to 2-3 cm length and 2-3 mm thickness. It is stored in silos for processing. Calcium carbonate powder of fine mesh is made into a slurry with water and circulated in a packed tower. Sulphur-di-oxide gas is passed into the tower where calcium carbonate slurry is being circulated. The wood chips from storage silos are charged into digester and then the cooking liquor is pumped into the digester, where the chips are cooked with steam at a temperature of 140°C for 7-8 hours. Under this condition, sulphur-di-oxide reacts with lignin and forms soluble compounds. So, slowly lignin dissolves leaving cellulose fibre. Then the cooked pulp is discharged into blow tanks and washed to remove about 90% of spent liquor. Washed pulp is taken for screening to remove uncooked wood chips. Then the pulp is bleached and fed to thickener to concentrate the pulp and collect in pulp chest, from where it is made into sheets in sheeting machine.

The wood pulp, chemically known as cellulose is steeped in 18% caustic soda solution and the excess caustic soda is pressed out mechanically. The resulting product, called Alkali cellulose, is disintegrated into fine crumbs mechanically and aged in small tanks for a period of about 24 hours. The tanks are mechanically lifted to the top floor of the factory and dumped into the Xanthating machine where it is treated with CS_2 liquid. The resulting Xanthate is dissolved in dilute caustic soda solution. This solution, called Viscose flows by gravity to the mixing machines situated beneath them where it is mixed very well to get a homogeneous solution. It is then pumped to the ripening room where the viscose is filtered thrice, the air bubbles are removed from the solution and pumped to spinning.

In case of staple fibre, the solution passes through spinnerettes made of gold and platinum having 23000 holes. As soon as the solution comes in contact with dilute H_2SO_4 mixed with sodium sulphate and zinc sulphate the cellulose in the viscose is regenerated and comes out in the form of yarn.

In case of Rayon, the viscose flowing through spinnerettes made of gold and platinum having 28, 40 and 36 holes comes in contact with spin bath containing H_2SO_4, sodium sulphate and zinc sulphate and the cellulose is regenerated from viscose, comes out in the form of yarn.

Simplified process flowsheet is shown Figure 1. Yearly production statistics and main raw materials consumed are depicted in Table 1 and 2. Environmental organisation chart of the industry is shown in Figure 2.

III. AUDIT APPROACH

Keeping in-view the nature of industry, the Environmental Audit programme was carried out in three phases:

Phase 1 : Pre-audit activities
Phase 2 : On-site activities
Phase 3 : Post-audit activities
The overall audit approach is depicted in Figure 3

Pre-audit Activities

The pre-audit activities of the project was commenced with the development of an audit plan, which included the scope of audit, priority topics selected, and explanation of the audit procedure. Then audit team made a visit in order to gather background information and administer questionnaires. The main objective at this stage was to minimise the time requirements for on-site audit and maximise team productivity.

On-site Activities

This phase began with a meeting of the audit team with the concerned personnel of the industry. The process engineer, in brief, presented the activities regarding the process and pollution control measures undertaken by the industry. The audit team familiarized themselves with different processes within the industry. Sources of liquid and solid wastes and their causes were identified. Audit team identified the waste water sampling locations, ambient, noise and stack monitoring locations and professional judgement was used in selecting the type and size of sample required to verify the key controls. All observations were documented. Material and energy measurements were also undertaken alongwith study of health and safety aspects.

The on-site phase was concluded with a close out meeting between audit team and management.

Post-audit Activities

The draft report was prepared incorporating the material, water and energy balance scenarios, which was sent for comments. After receiving comments from their end, Final report was submitted for their consideration and follow up action. An Action Plan was suggested based upon the recommendations.

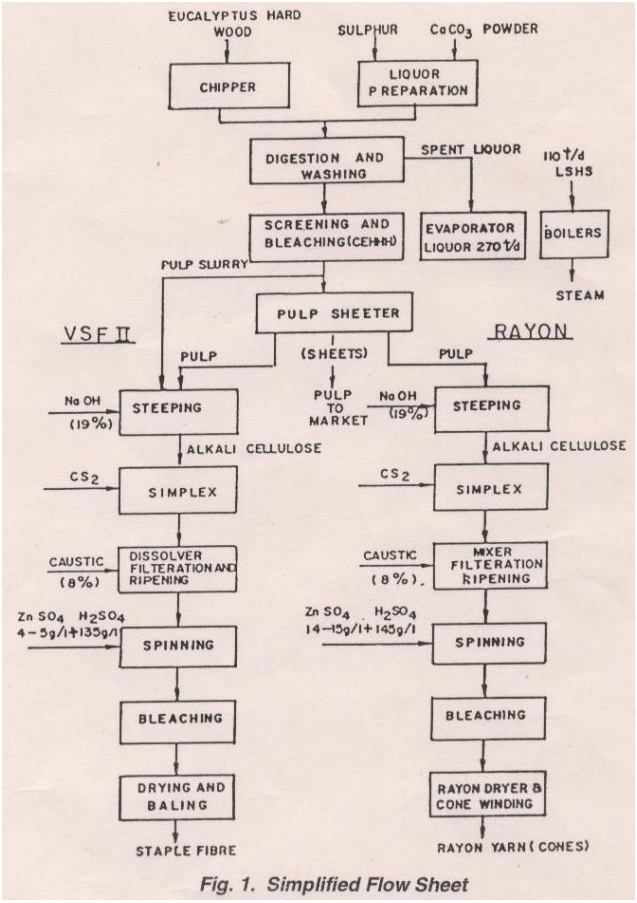


Fig. 1. Simplified Flow Sheet

IV. MATERIAL AUDIT METHODOLOGY

Keeping in view the process activities envisaged, size of the industry, it was decided to conduct studies on pulp process units and utilities. Available information on different process units involved in the manufacture of pulp was collected along with data on the manufacture of rayon, Viscose Staple Fibre, sulphuric acid and carbon-di-sulphide.

Suggestions

1. In Chipping unit, during chipping process the undersized chip pieces and the saw dust amount to about 10 Kg per 1000 kg of wood charged. But due to operational problems and controlling system the waste material is not recovered through the blower system which is already existing to collect the saw dust and reuse in boiler and in other places as, fuel. Some of the material is still lost as waste solid material. BY regularising the proper dust collecting system the chipped material can be recovered in larger quantities to reduce the solid waste in the chipper section. At present the loss of wood in chipper section is about 1 to 2%.

This can be reduced to about 0.5 to 0.75% by regularising the waste collection systems.

2. In pulp plant, about 150 tons of pulp is produced per day. The pulp plant consists of chipper and digester, extraction, and drying. During liquor washing, loss of pulp is identified as 1%, which can be reduced to 0.6-0.7% by proper inhouse control. The major loss of pulp is in screening section which is about 5% due to oversize of cooking material. The washed oversized material can be collected.

Table1. Yearly Production Statistics

SL. No.	Category	Unit	April 02 to March 03	April 03 to March 04	April 04 to March 05	April 05 to March 06
1.	Rayon Yarn	Tons	5109	4706	4663	4909
2.	Wood Pulp	Tons	42715	45015	46025	51103
3.	Viscose Staple	Tons	13123	14628	14339	19220
4.	Sulphuric Acid	Tons	26257	30594	44681	35632
5.	Carbon-di-sulphide	Tons	3787	4566	4047	5592
6.	Anhy. Sod. Sulphate	Tons	7469	5427	6120	7922

3. 4 tpd of pulp is wasted during bleaching process as rejects in pulp [Slant]. The same can be collected and processed further for second grade pulp which is economically valuable.
4. Tests on digestor were conducted in pulp plant to identify the time requirement for the total process as well as for digestion process. Two digesters have been selected for carrying out the performance test. Performance tests reveal that the time taken for actual digestion of pulp can be reduced by increasing the free SO2 concentration, in CBS liquor which is used as digestion liquor. It is suggested that SO2 concentration of CBS should be maintained around 5.0-5.5% for reducing for a day which is economically beneficial.
5. In pulp plant, sulphur is used mainly to produce sulphur-di-oxide which is used for preparation of calcium bisulphite (CBS). During CBS preparation lime stone is reacted with SO2 under chilled water conditions. The sulphur required for the reaction is about 0.165 t/t of pulp, where as it is found that the sulphur quantity is used upto 0.205%t/t of pulp.

In comparison, an excess amount of about 0.04 t of sulphur/t of CBS can be saved if proper stochiometric quantities of chemicals are used for CBS preparation.

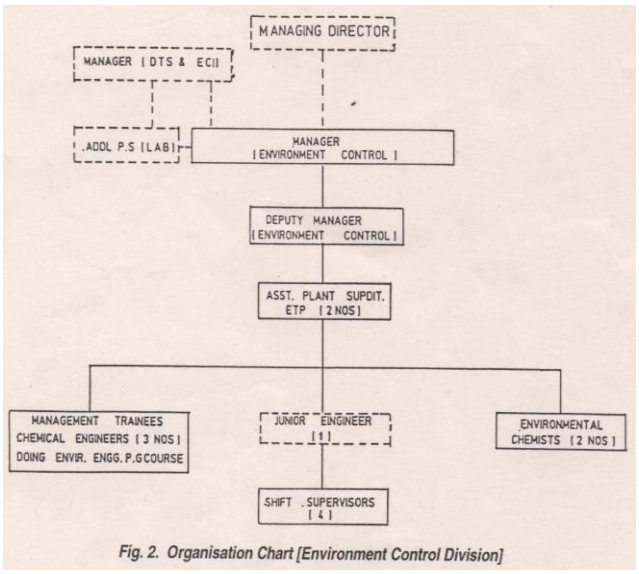


Fig. 2. Organisation Chart [Environment Control Division]

Table 2. Main Raw Materials Consumption

Raw Materials	**Unit**	**2002-03**	**2003-04**	**2004-05**
Pulp Wood	Tons	141521	148064	164250
Sulphur	Tons	23099	26538	26582
Liq. Chlorine	Tons	1610	1469	1972
Caustic Soda	Tons	15941	15247	20312
Limestone	Tons	9260	8916	9493
Charcoal	Tons	2074	1851	3204

Methodology

Basic data regarding operational features and working of various process units, overall energy consumption, its

cost and production figures for the last 3 years was collected. These figures, when compared, gave a trend of energy consumption and its cost per unit production over the year. When sufficient data was built-up, existing records of consumption was reviewed and measurements were taken wherever necessary using portable instruments.

"Pie-diagram of energy consumption" was prepared to indicate the share of various forms of energy in the total energy consumption of the plant and is depicted in Figure 4.

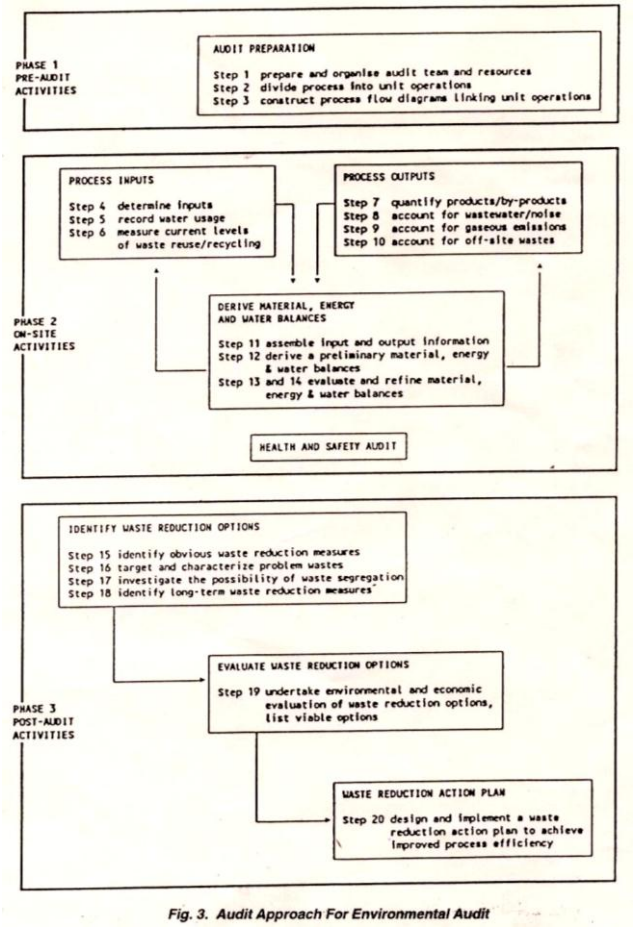


Fig. 3. Audit Approach For Environmental Audit

V. ENERGY AUDIT

SUGGESTIONS

Transformer Load Management

1. The 2 x 1500 KVA 22 KV/415 V transformers in the main outdoor substations have been loaded far below the optimum loading ratio. The percentage loading is about 28.75%. In view of minimising the transformation losses it is recommended to open 1 x 1500 KVA transformers on the primary side in cyclic rotation of one week.

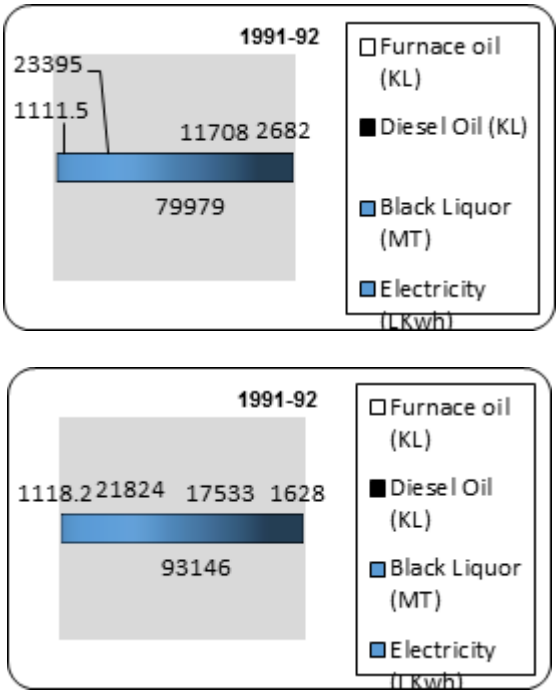


Fig.4. Energy Consumption Pattern

2. The 2 x 1500 KVA 22 KV/415 V transformers in the Effluent Treatment Substation have been underloaded. The percentage loading being 31.15% is below the optimum loading ratio. Hence to minimise the transformation losses it is recommended to open 1 x 1500 KVA transformer on the primary side in cyclic rotation of one week.

Power Factor Management

3. The Turbo Generator sets No. 1 and 2 are being operated to generate necessary reactive power to compensate the reactive power demand of the load. The reactive power demand of the load is on the higher side inspite of the capacitors provided on the 6.6 KV and LT bus. Further an additional load of about 6 MVA has been expected in short future due to expansion projects on hand. In view of improving the efficiency of TG sets, reducing the maximum demand and improving the overall plant power factor it is recommended to :

- ✓ Provide Capacitor Banks of capacity 2 MVAR on the 22 KV side at the main outdoor substation with necessary reactors, switch gear etc.
- ✓ Operate the TG sets at an optimum power factor i.e., between 0.85 to 0.9.

Replacement of Over Sized Motors

4. Agitator motors of 30 kW rating. 7 Nos. art found to be highly underloaded. It is recommended to replace these motors by 15 kV motors.
5. Exhaust blowers No. 4 and No. 6 are found to be underloaded. It is recommended to replace these motors by 40 kW motors.
6. Digester circulation pump-5, condensate pump, liquor transfer pumps 4754 and 475J and raw effluent pump 1 are observed to be underloaded. It is recommended to replace these motors by smaller size motors.
7. It is recommended to replace the existing motors by smaller size ones in the following fans as they are under loaded.

   a. Air supply fan 152/A
   b. Drier fan 8353
   c. Drier fan 8314
   d. Air blower ETP 1
   e. Air blower ETP 2
   f. Aerator No.30

Providing PF controllers

8. The slurry press motors 4 nos. of 30 kV each operate at low power factors and unde varying load conditions. It is recommended to provide PF controllers (Electronic Energy Saving Devices), for these motors.

Heat Recovery from Charcoal Calcining

9. Charcoal is calcined at 200-400° C fc about one and half hours in an open furnace to remove volatiles. During calcining, hot flue gases at 450-680° is vented to atmosphere without any heat recovery. The heat content of flue gas is equal to 176 kgs of LP steam per hour. It is suggested to recover this heat by preheating W.H. boiler feed water from 30° to 60° using a heat exchanger.

Heat recovery from Hot Ammonia Refrigerant Gas

10. Chilled water for CS2 plant is generated using ammonia refrigeration system. During compression, ammonia gas is heated to about 120°C and condensed in shell and tube condensors with cooling water. About 42670 K.Cal/hr of super heat is available in the hot compressed ammonia gas which is wasted into the ambient air through cooling tower. It is suggested to recover this super heat by preheating WH boiler feed water.

Cooling Tower Fan Control

11. Warm water from ammonia refrigerant condenser and furnace primary condenser is cooled in an induced draft cooling tower. It was observed that due to low thermal load, the cooling tower outlet temperature was equal to ambient wet bulb temperature. It is suggested to provide a temperature sensor in the cooling tower water outlet so that cooling fan can be switched off whenever the water temperature reaches 2°C higher than the ambient wet bulb temperature.

Insulation of VSF 1, 2, & 3 Dryers

12. Wet staple fibres are dried in hot air circulated drum driers. Dryer inside temperature is maintained at 100°C for VSF 1 and 160° for VSF 2 & 3 dryers. The average surface temperatures were found to be ranging between 40 to 45°C. Generally continuous driers are adequately insulated so that its skin temperature does not exceed 50°C higher than the ambient temperature. But higher skin temperatures are allowed only in small and intermittently operated dryers. Since these dryers are operated continuously, it is suggested to increase the insulation thickness to minimise heat loss.

Recovering Steam Condensate from VSF 1,2 & 3 Dryers

13. Steam condensate from the fibre dryer air heaters are collected and utilised in the after treatment section instead of sending to boiler plant even though the condensate return facility is already existing. Since hot DM water is expensive than hot soft water, it is suggested to return to boiler plant.

Heat Recovery From Spin Bath Concentrator - Steam Condensate

14. Return spin bath is heated from 50° to 70° in VSF 1 and from 40° to 70° in Rayon bath recovery section in a heat exchanger using LP steam. About 6.75 tons/hr of steam condensate at 90° is drained because of acid contamination. It is suggested to preheat the Rayon spin bath from 40° to 46° in a new SS 316 heat exchanger with steam condensate

and further heating upto °C in the existing heat exchanger using LP steam.

Insulation of Rayon Tunnel Dryer

15. Wet cakes with an initial moisture content of 150% is dried to a final moisture content of 7% in three tunnel driers which are maintained at 65°C. The average surface temperature of the second zone is about 45°C which is high for a low temperature continuous dryer. Hence it is suggested to increase the insulation thickness so that its skin temperature is just 5°C higher than ambient temperature.

Recovering Tunnel Dryer Steam Condensate

16. Hot water at 95°C is circulated in the tunnel dryer coils. The return hot water at 80°C is further heated to 95°C in a heat exchanger. The resultant steam condensate (about 1.6 T/hr) is used in the bleaching section as hot water. It is suggested to pump back the steam condensate to boiler plant rather than using in the process.

Twin Lobe Blower

17. Excess water from wet rayon cakes is removed by passing warm air at a pressure of 0.6 kg/cm from a twin lobe blower. Since the air consumption is less than the generation, blower frequently reaches the maximum set pressure of 0.8 Kg/Cm . Air is also continuously leaking from the relief valve as its setting is also at 0.8 Kg/Cm^2. To avoid air wastage, it is suggested either to deaerate the blower or provide an air receiver and change the blower maximum settings from 0.8 to 0.7 Kg/Cm .

Raising Steam Pressure in WH Boiler

18. Stable fibre dryers need about 8.0 tons of MP steam per hour at 17.0 KG/Cm^2. Presently MP steam is supplied from power boiler through a pressure reducing station, thus by passing the turbines. About 272 units/hr can be generated, if entire steam is passed through the turbine. Hence it is suggested to increase the operating pressure of WH boiler to 17.0 Kg/Cm and supply steam to driers instead of from power boiler.
19. It is suggested that heat may be recovered from paper sheeting machine by installing heat pipes, which may be used to preheat the air supplied to dryer.

Drawing Fresh Cold Air

20. The compressor room temperature from where the compressor intake air is drawn is 5°C higher than the ambient air temperature of 31 °C. Every four degree centrigrade increase in intake air temperature results in one percent extra energy for compression for the same quantity of air. Hence it is suggested to draw fresh air from outside through ducts. Care should be taken to minimise pressure drop in the suction line by providing enough diameter pipe.

Cleaning Inter Coolers in Air Compressor

21. Inter cooler outlet temperature from Khos-la:2 compressor was 15°C higher than the normal designed temperature of 45°C which indicates that the tubes inside the intercoolers are fouled or water lines are choked. Such hot air entry into the second stage will reduce the efficiency of compressor (1% for 4°C rise). It is suggested to clean the intercoolers.

Heat Recovery from after Cooler

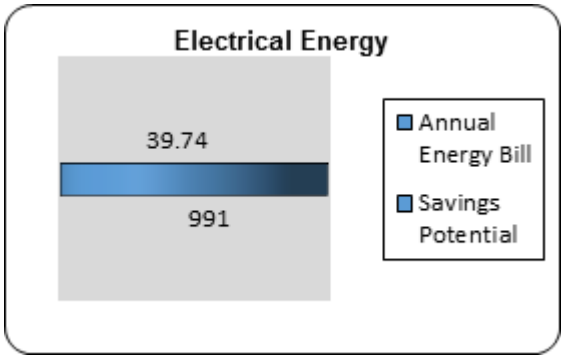
22. It was observed that the Khosla compressor (Sulphur Burner Compressor) cooling water outlet temperature was about 62° which is presently drained. Since the heat content is considerable, it is suggested to utilise the warm water in pulp plant bleach section.

Energy conservation potentials for electrical and thermal energy is shown in Table 3 and depicted in Figure 5.

VI. WATER AUDIT

Methodology

Water audit conducted aimed at evaluation of raw water intake facilities, performance evaluation of existing water treatment plants, water consumption in different processes and development of water balance scenario high-fighting water conservation measures.



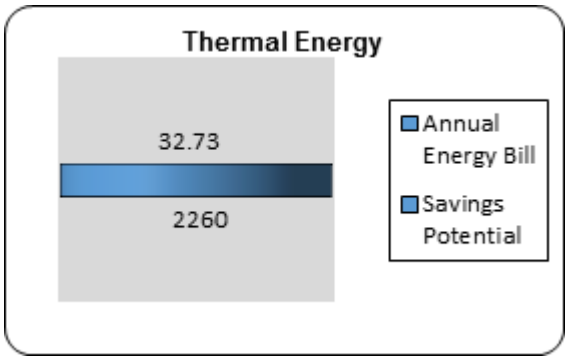


Figure 5. Energy Conservation Potential

SUGGESTIONS

1. Design details of the old and new water treatment plants are not available with the industry and hence performance evaluation has not been done.
2. Jar test is not being conducted regularly and alum is being added irregularly without any precise measurement, presently, 30 mg/l of alum is being added without any jar test. Jar test should be conducted regularly. Turbidity meter should be provided in both the treatment plants by the management to measure the turbidity of incoming raw water.
3. Total water requirement in chipper house is 626 m /day. By segregating ejector and pump cooling water from digester house (264 m^3/d) and reusing the same in chipper house flume reduces the total requirement by 360 m /day which saves Rs.96,000 per annum, whereas installation of piping costs around Rs.20,000.
4. Total fresh water requirement in first screen area is 6000 m^3/d excluding the warm water requirement. The backwater overflow from inter-mediate pulp storage chest is contaminated with fibres only and hence 3100 m /day of water can be recycled for pulp dilution in common screen.

The pictorial representation of water usage is shown in Figure 6.

Water balance scenario has been developed and shown in Figure 7.

Table 4 depicts the annual savings and payback periods for implementing the suggested measures.

VII. ENVIRONMENTAL QUALITY AUDIT METHODOLOGY

1. Ambient Air Quality monitoring was carried out to assess the status of existing air quality within the industries complex.
2. In order to quantify the stack emissions, stack monitoring was carried out at steam boiler, liquor preparation section of pulp plant, VSF, Rayon, H_2SO_4, and CS_2 plants.

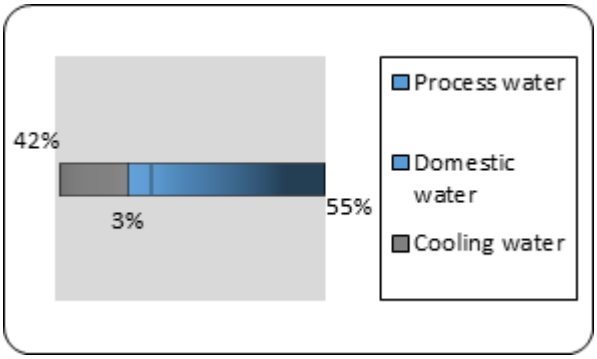


Figure 6. Pictorial Representation of Raw Water Usage

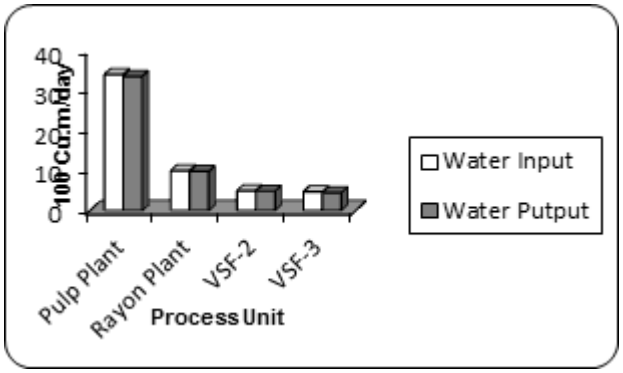


Figure 7. Water Balance Diagram

Table 4. Water Conservation Potential

SL. No.	Measures	Estimated Investment (Rs.)	Savings (per annum) Rs.	Pay-back Period Yrs.
1.	Water reuse in chipper house	20,000	96,000	2.5
2.	Pressured water supply	-	-	-

3. Monitoring of sectional and combined wastewater discharges were carried out. Performance of evaluation of Effluent Treatment Plant was also undertaken.
4. Workzone monitoring was carried out to know exposure concentrations.
5. Noise levels were measured after identifying critical noisy zones.
6. Existing facilities for handling/disposal of solid/hazardous wastes were critically examined.

SUGGESTIONS

1. Gaseous pollutants like SO_2, and NO_X from pulp plant boiler stack are on higher side compared to CPCB standards. High SO_2 content is due to higher sulphur content in the liquor which is used as a fuel in boiler, whereas NOx and CO shows the incomplete combustion of fuel. For improved combustion techniques following measures should be adhered to.
   a. Proper burner maintenance.
   b. Good atomisation of liquid fuel.
   c. Provide bio-scrubbers or wet-scrubbers for controlling SO_2 content in the emissions.
2. All SPM, SO_2 and NO_X concentrations were below prescribed limits suggested by CPCB for industrial/ mixed zones. Higher concentrations were observed in down-wind directions,
3. Work zone monitoring results shows that all places concentrations are within limits prescribed by TNPCB. However, higher concentrations recorded at some places show leakages in the process. So, it is suggested that leakages in the process/ equipment should be detected and measures are to be taken to control the same to protect the workers health and conservation of raw materials.
4. During the study period, it was observed that, considerable odour problem exists and hence it is advised that the industry has to initiate necessary odour control measures.
5. During study period two equalisation tanks were in operation. It is suggested that running of two equalisation tanks simultaneously is not required.
6. As a standard practice, air flow rate should be in the range of 0,01 to 0.0115m^3 of air/m^3 of tank to maintain the solids in suspension. So, for a tank of 9500m^3 capacity, the air flow rate should be 5700 m^3/hr. Considering the capacity of existing air blowers i.e., 2450 m^3/hr each, even if two blowers are operated simultaneously, the air supply will be insufficient to keep solids in suspension, resulting in accumulation of solids in equalisation tank.
7. At present, lime is used to rise pH to 7.0 at equalisation tank for subsequent precipitation of zinc in clarifloculator. But, for optimum zinc removal, pH should be at 11.0. Therefore due to present low pH conditions, zinc removal efficiency is low. With the existing treatment scheme it is technically not feasible to meet prescribed limit for zinc of 1 mg/1 by lime precipitation alone. At present Zn concentration is 1.2 mg/1 in the final effluent.
8. In case of aerated lagoons, the flow is not being divided properly and sufficient submersion for aerators is not being maintained. Hence the desired effluent standards are not being met.
9. Provision of pre settling tanks is a must for pulp plant effluent. Total effluent from pulp section is 1300 m /hr. Construction of presetting tank of 20 m x 30 m x 3 m is recommended to settle the fibrous material can settle and settled material can be sold at a rate of around Rs.200/t. With this provision, frequent cleaning of equalisation tank is not necessary (presently cleaning is done two times in a year spending around Rs. 1.50 lakhs).
10. As the existing effluent treatment plant cannot meet the stipulated standards, it is suggested to have extended aeration process which need one settling tank after aerated lagoons I & II. So, a circular tank of 40 m diameter and 3 m depth can be constructed with provision for recirculating the sludge to maintain 4000 mg/1 MLSS concentration in the aerated lagoon. Excess sludge can be sent to the existing vacuum filter. With this, 95% BODs can be removed and zinc concentration can be reduced to less than 1 mg/1 in the final effluent.

A schematic diagram of these modifications is shown in Figure 8.

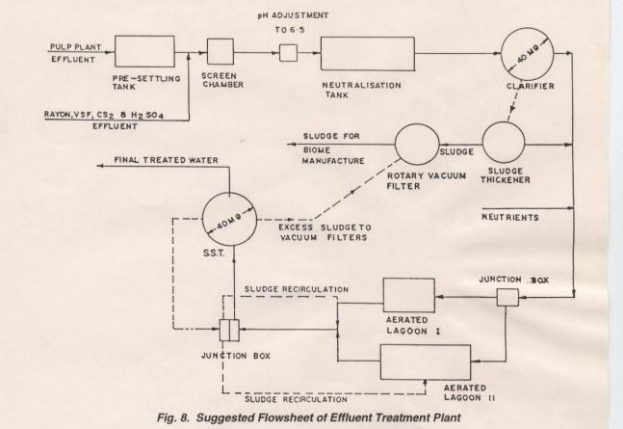


Fig. 8. Suggested Flowsheet of Effluent Treatment Plant

11. With due consideration to techno-economic feasibility, it is suggested to segregate the following and appropriate treatment to be given.
    a. High concentration zinc bearing effluent from VSF and Rayon sections.
    b. Acid condensate stream which contained high BOD from wood pulp plant.

12. Zinc recovery/ treatment options for zinc rich effluent streams. The viscose staple fibre and rayon plant discharges the effluent with rich content of zinc. It is known that zinc can be precipitated from a zinc bearing solution by the addition of lime and maintaining a pH of 9 in the treated solution or by using NaOH at a pH ranging from 9.3 to 9.5. Based on these principles, a method has been devised in which raw wastewater is first treated with lime to raise its pH to 6 and the treated effluent can be settled to remove the mixed precipitates of calcium sulphate and zinc hydroxide. The supernatant is then treated with caustic soda and its pH adjusted to 9.2 where almost complete precipitation of zinc as hydroxide occurs.
13. Colour removal from final effluent is a must before discharging to river.
14. As extended aerated lagoon system is suggested there is no need of treating it again in Aerated Lagoon III. They can directly discharge into river, Bhavani. By stopping all 7 aerators in aerated lagoon III, they can save an amount of Rs. 43,45,000 per annum.
15. Near boiler, compressor room and new H_2SC_4 plant sound levels were observed to be more than 90 dBA. So, workers in these areas should be fined if they don't use ear muffs.
16. Though the industry has provided ear muffs, it was observed that most of the workers are not using them.
17. Noise awareness programmes should be conducted among the workers.
18. Based on CRIT criteria proposed by ERA effluent treatment plant sludge has been characterized for leachate as well as total sludge characteristics. Sludge generated from ETP falls under hazardous waste category No.12. It is felt that after recovering zinc from ETP sludge, present practice of disposal (converting into BIOME) should be continued.
19. Quantity of ash generated in boiler house due to combustion is 19t/day. At present, simply it is being disposed off without proper precautions. Disposal may be carried out as inland fill.
20. Filter cloths are regularly washed and reused. The washings are routed to individual drainage. Unusable washed filter cloths are only dumped in land fill sites.

VIII. HEALTH & SAFETY AUDIT

Methodology

Preliminary information (through Questionnaire, Protocols) on health/safety aspects was collected. Accidents through audit exercises, pre-audit meetings and inspection alongwith perusal of records and study of key documents was done. As a part of Health and Safety audit, damage distances were also calculated and suggestions were given for improvement in these aspects.

SUGGESTIONS

1. It is recommended that the safety function be reinforced to give special emphasis to occupational health aspects such as work area toxics.
2. The storage of chlorine in the pulp plant needs a closer examination and provision to deal with any damaged tonners needs to be made.
3. The safety organisation, though adequate to meet the requirements of Factories Act, does not provide expertise and facilities for analysis and investigation of work area toxics. It is recommended to have a suitable person wit specific responsibility of dealing with the occupational health factors.
4. Accidents should be avoided while feeding logs to the flume in chipper section of pulp plant.

5. A mild chlorine leakage in bleaching section of pulp plant is observed which has to be avoided.
6. Major number of reportable accidents are caused in wood yard and chipper section (50%) and sheeting section including baling section (35%). Hence, workers require proper guidance in "material handling" to avoid accidents.
7. During audit, broken door glass, broken godet, broken funnel, blocked spinneret, damaged pot cover in Rayon spinning section, worn out flanage packing in VP section, leaking valves in spinning section were observed which are "unsafe condition" and has to be rectified at the earliest.
8. Slippery floor in CS_2 plant and damaged step of a ladder in Rayon bleaching section can be classified under "poor house keeping" which requires proper attention.
9. Wet floor and spurting of hot pulp from alkali tower causes unsafe conditions in pulp plant.
10. More stress on communications between the management and employees on safety is essential so that it creates an awareness of the necessity for employee management acceptance of the safety programme and they work together to achieve the goal.

EPILOGUE

1. Water audit studies have indicated that it is possible to save an amount of Rs. 0.96 lakh per annum.
2. Secondary wastewater treatment facilities need to be improved to make the effluent conform to prescribed standards and ash generated in boiler house should be disposed off as inland fill. As a conservative measure, even if aerators are stopped alone (in Aerated lagoon III), a saving to the tune of Rs.43,45,000/- per annum can be achieved.

3. Energy conservation opportunities exist in major areas like TG sets, substation, Rayon & VSF spin bath and acid plant waste heat boiler and it is possible to save an amount of Rs.72.47 lakhs per annum by adopting the energy conservation measures.

Environmental Audit measures, if implemented as per the recommendations given, will result in savings to the tune of Rs.125 lakhs per annum.

Outcome of this study reveals that the Environmental Audit has enormous potential for achieving increased productivity and improved environmental conditions. It can be viewed as a central theme for sustainable development.

IX. REFERENCES

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