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Environmental Audit - A Management Tool for Climate Change

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Abstract— **The paradigm of sustainable development warrants implementation of preventive environmental management measures, like environmental audit which is an instrument for 'resource conserving modes of manufacturing. So far, in India, environmental regulations focused mainly on pollution control through end of the pipe treatment technologies which allow the wasteful use of resources first and consume further resources to solve the environmental problems in a particular medium. This paper aims to substantiate the contention that the use of environmental audit practice helps an industry to increase its productivity; through a case study conducted within a viscose industry, situated near Chennai and focuses the environmental audit as an effective pragmatic management tool for climate change.**

Index Terms—**Paradigm, pipe treatment, pragmatic management.**

I. INTRODUCTION

India has been diversifying into progressively more capital intensive and energy intensive areas which are degrading the quality of environment. It is generally perceived that environmental conservation is a stumbling block in the development of industrial activities. The pollution control approach to environmental management is a legalistic paradigm that comes into force only after a violation has been made and, accordingly, does not pre-vent pollution and concomitant wasteful utilization of resources. In this pollution control approach, industrial production is relegated to a black box exerting controls at the end of the pipe thereby excluding the possibilities of pragmatic waste management through changes in raw materials and products, production processes and byproduct recovery. Further, pollution control approach does not include internalization of environmental damage costs as the public find it economically advantageous to pay penalties rather than comply with regulations. Considering the future environmental and energy scenarios, the impact, the industry has on environ-mental quality, environmental audit (EA) deserves to be adopted as a pre - requisite for sustainable development and environmental management of Indian industries. Environmental audit (EA) is a structured and comprehensive mechanism for ensuring that the industrial activities do not adversely affect the environmental quality and the economy of the industrial sector improves as a consequence of improved process and energy effectivity as also the occupational health and safety. Recognizing the importance of environmental audit, procedure for environmental audit was first notified under the Environment (Protection) rules, 1986, by the Ministry of Environment and Forests (vide their notification No. GSR 329 (E) dated 13th March, 1992), the industrial units are required to furnish environ-mental audit reports. By an amendment (vide their notification No. GSR 386 (E) dated 22 April, 19 93), the term for the document has been revised from 'Environmental Audit Report' to 'Environmental Statement.'

Environmental statement has to be submitted by each industry, requiring consent under section 25 of the Water (Prevention and Control of Pollution) Act of 1974 or under section 21 of the Air (Prevention and Control of Pollution) Act of 1981 or both or authorisation under the Hazardous Wastes (Management and Handling) Rules of 1989 issued under the Environment (Protection) Act of 19 86. The statement has to be submitted to the concerned State Pollution Control Board for the period ending on 31 March in a prescribed format by 30 September every year, beginning from 1993. The prescribed proforma has nine parts (A to I) and covers the items, like water and raw material consumption, pollution discharged to environment per unit of output of the parameters specified in the consent, hazardous wastes from the pollution control facilities, solid wastes from the process and from the pollution control facilities, impact of pollution abatement measures on conservation or natural resources, and on cost of production.

Table 1. Yearly production statistics, in tone

Category	April 89 to March 90	April 90 to March 91	April 91 to March 92	April 92 to March 93
Rayon yarn	5109	4706	4663	4909
Wood pulp	42715	45015	46025	51103
Viscose staple	13123	14628	14339	19220
Sulphuric acid	26257	30594	44681	35632
Carbon disulphide	3787	4566	4047	5592
Anhy. sod. Sulphate	7469	5427	6120	7922

Table 2. Main raw materials consumption, in tone

Category	1990-91	1991-92	1992-93
Pulp wood	141521	148064	164250
Sulphur	23099	26538	26582
Liq. chlorine	1610	1469	1972
Caustic soda	15941	15247	20312
Limestone	9260	8916	9493
Charcoal	2074	1851	3204

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Although the initial attempts are being made in India to establish the practice of environmental audit; it can be said that the environmental audit is not a totally new concept, but it is certainly a brand new practice. A typical optimisation approach characterizes the process of environmental audit. Environmental audit is not merely a step to comply with the requirement to furnish an annual environmental statement. The importance of environmental audit lies in introspection and enlightened self interest. Environmental audit is a practice with great potential for achieving increased productivity and improved environmental protection. Keeping in view the aforementioned aspects, an in depth environmental audit study was conducted in a viscose industry near Chennai to demonstrate the hidden benefits, which is delineated here.

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, ha-rd 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 dioxide 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 hr. Under this condition, sulphur dioxide 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.

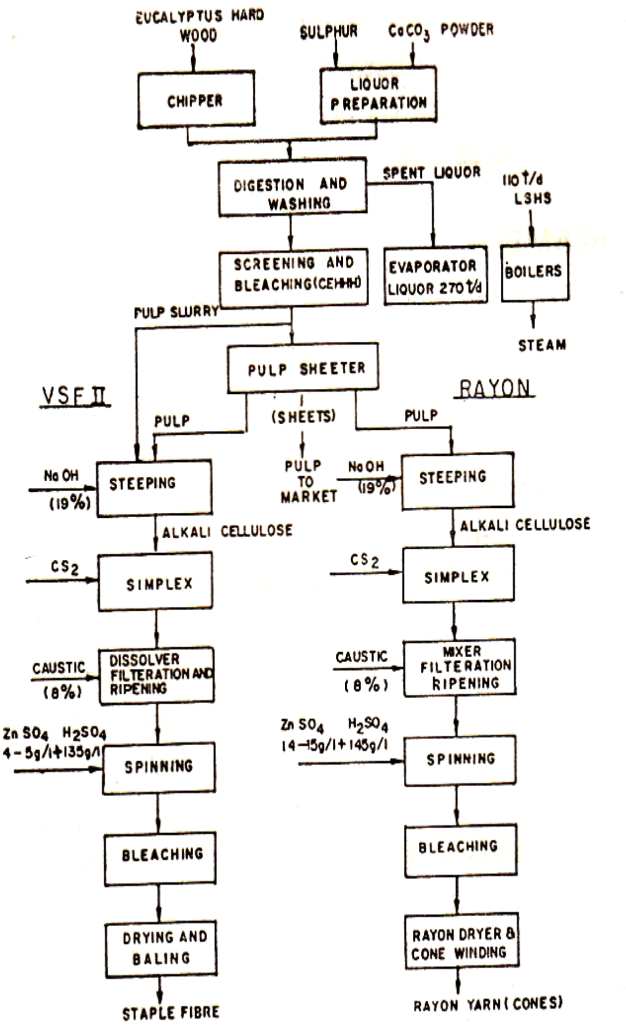


Figure 1. Simplified flow sheet

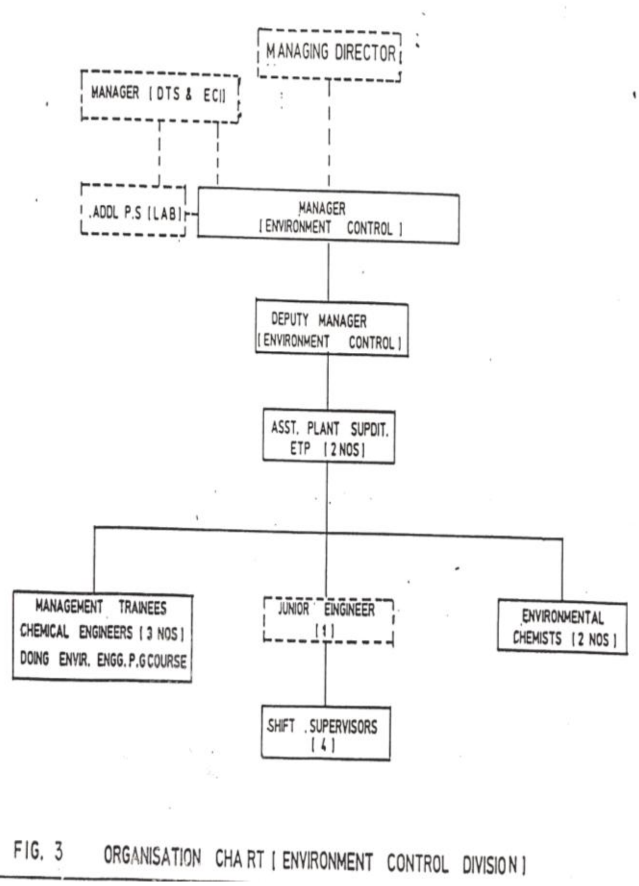


Figure 2. Organisation chart (environment control division)

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 hr. The tanks are mechanically lifted to the top floor of the factory and dumped into the Xanthating machine where it is treated with CS, 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 flow sheet is shown in figure 1. Yearly production statistics and main raw materials consumed are depicted in tables 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 phase:

Phase 1: Pre - audit activities,

Phase 2: On - site activities, and

Phase 3: Post - audit activities. The overall audit approach is depicted in figure 3.

A. 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.

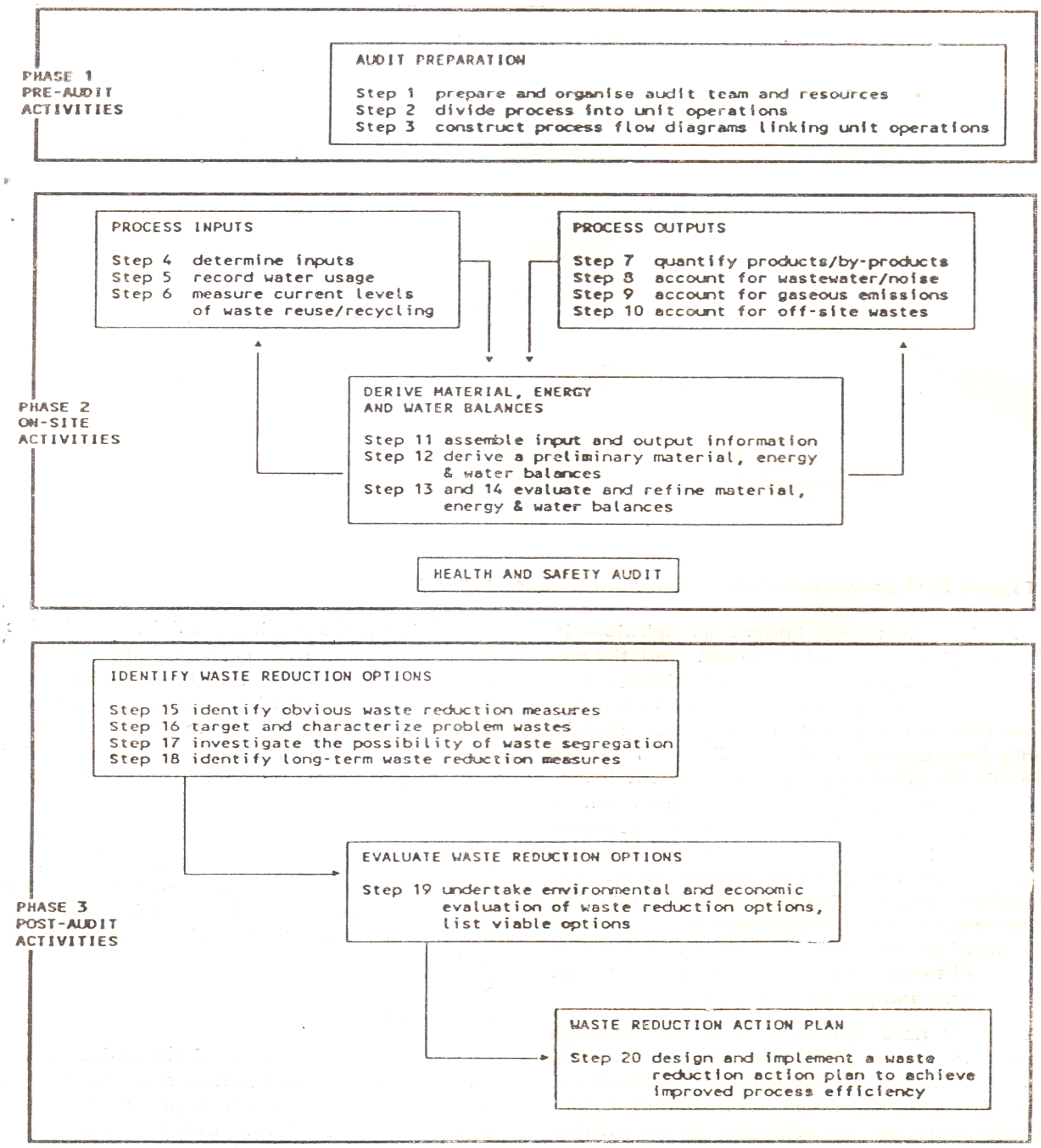
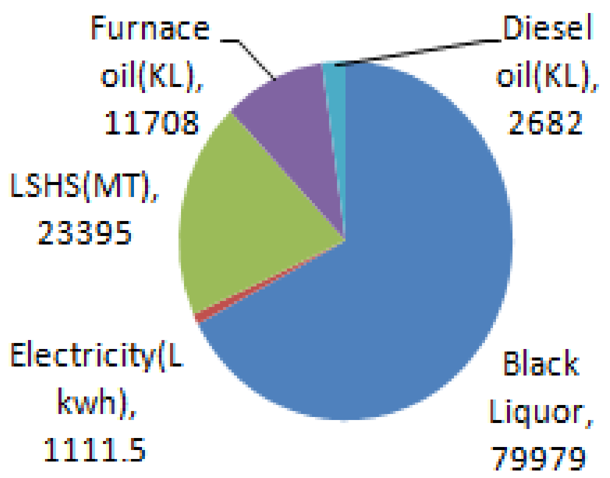


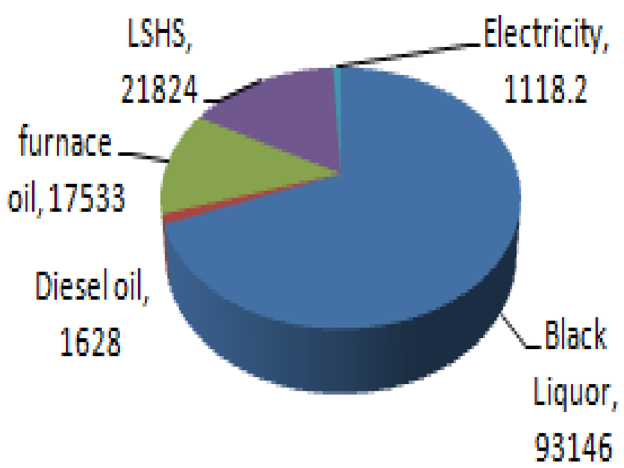
Figure 3. Audit approach for environmental audit

B. On-site activities

This phase began with a meeting of the audit team with the concerned personnel of the industry. The

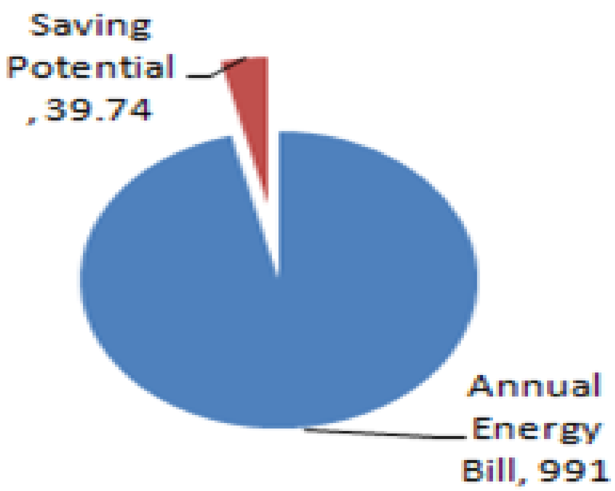


1991-92

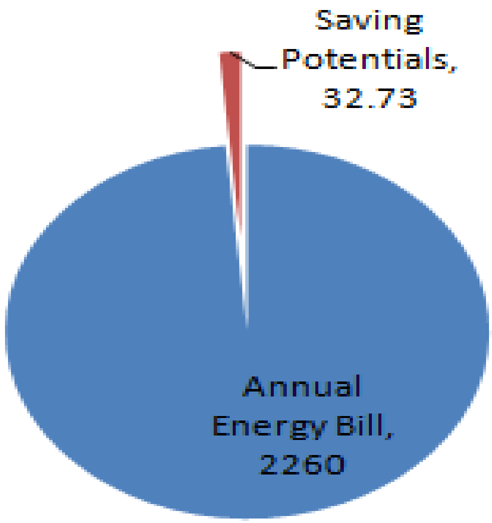


1992-93

Figure 4.Energy consumption pattern



Electrical Energy



Thermal Energy Figure 5. Energy Conservation potential

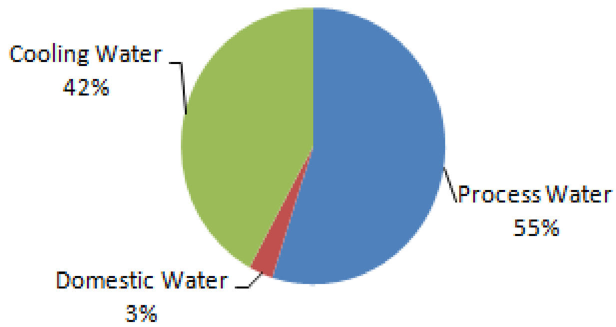


Figure 6. Pictorial representation of raw water usage

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 wastewater 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 along with study of health and safety aspects. The on - site phase was concluded with a close out meeting between audit team and management.

C. 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.

IV. MATERIAL AUDIT

A. Methodology

Table 3. Energy conservation potential

Details of recommendations	Savings in steam		Savings in electricity		Cost of	Simple
	Tonne of steam/yr	Rs. in lakh/ year	Lakh kwh/year	Rs. in lakh/ year	implementation, Rs. Lakh	payback period, year
Electrical system						
Achieving optimum loading on distribution transformers at outdoor substation	-	-	0.135	0.27	Nil	I
Achieving optimum loading on effluent treatment substation transformer	-	-	0.119	0.238	Nil	I
Providing capacitor banks of capacity 2 MVAR on 22 KV side at the main outdoor substation % savings in maximum demand	-	-	900%	8.10	25	0.17
Operating TG sets at an optimum power factor - to increase active power generation and to improve efficiency of TG sets	-	-	72.93	12.29	-	-
Electric drives and lighting						
Replacement of oversized motors with optimum size ones in agitators, exhaust blowers, pumps and driers fans	-	-	0.912	1.82	5.43	3
Providing PF controller (electronic energy saver) for slurry presses	-	-	0.096	0.192	0.72	3.8
Switching off fluorescent lamps during 8 AM 5 PM in rayon spinning and rayon spindle expansion	-	-	0.87	1.74	Nil	I
Rational use of quality inspection table fluorescent lamps	-	-	0.19	0.38	M	I
Boiler, steam and process aspects						
Sensible heat recovery from boiler continuous blow down	315	1.16	-	-	1.0	0.9
Heat recovery from hot flue gases evolving during charcoal calcining	270	0.90	-	-	4.0	4.5
Heat recovery from hot ammonia refrigerant gas in CS_2, plant	375	1.35	-	-	4.0	3.0
Energy savings in controlling CS_2, plant cooling tower fan	-	-	0.097	0.194	0.20	1.0
Improving thermal insulation of viscose staple fibere dryers 1, 2, 3	583	2.34	-	-	4.2	1.7
Recovering steam condensate from VSF 1, 2 and 3 dryers and sending to boiler plant	36.3	0.362	-	-	0.25	1.7
Heat recovery from rayon VSF1 spin bath concentrator steam condensate	3675	14.7	-	-	15.0	1.0
Improving thermal insulation of three rayon tunnel dryer second zone	636	2.55	-	-	3.0	1.2
Recovering rayon plant tunnel dryer steam condensate	25	0.10	-	-	M	I
Derating rayon plan twin lobe blower or providing air receiver	-	-	0.343	0.685	0.70	1.0
Raising steam generating pressure	-	-	22.19	13.30	25.0	1.9

in acid plant waste heat boiler (generated electricity cost Rs. 0.60/unit)						
Sensible heat recovery from FFFF evaporator foul condensate	2252	9.0	-	-	10.0	1.1
Drawing fresh cold air from outside compressor house through ducts	-	-	0.11	0.22	0.25	1.1
Cleaning of intercoolers in Khosla 2 instrument air compressor in power plant	-	-	0.16	0.32	0.10	0.3
Heat recevery from Khosla compressor 4 used for sulphur burners in pulp plant	68.0	0.27	-	-	0.27	1.0
Total	8235.3	32.73	98.14	39.74	99.12	-

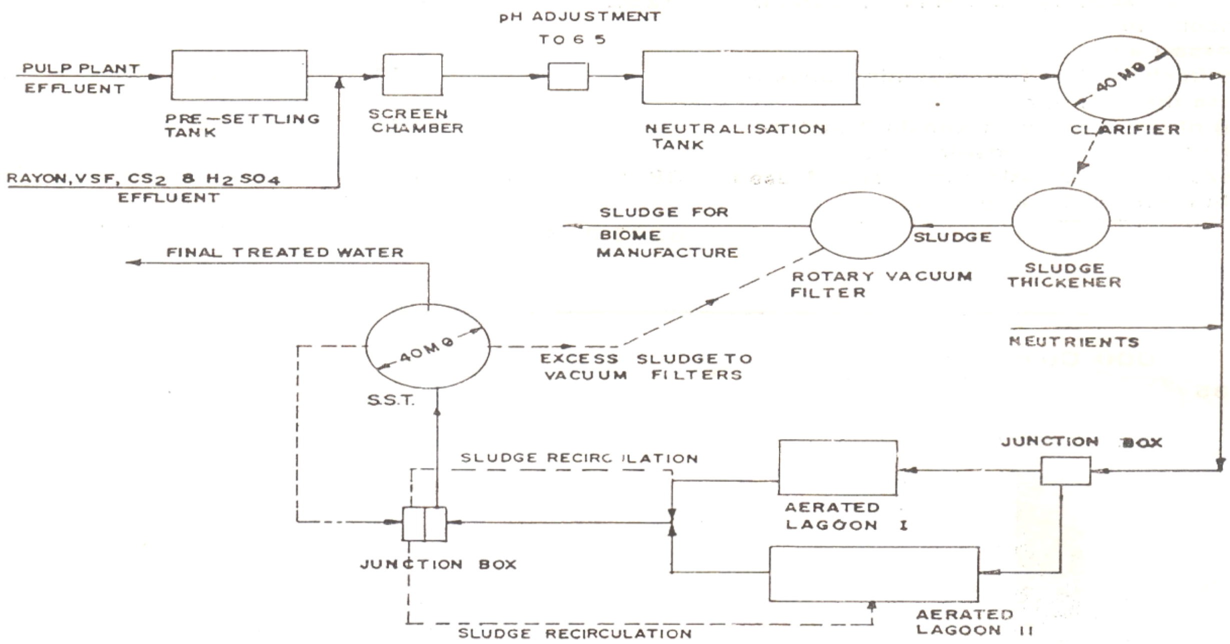


Figure 8. *Suggested flowsheet of effluent treatment plant*

Figure 8. Suggested flow sheet of effluent treatment plant

Table 4. Water conservation potential

Measure	Estimated investment, Rs.	Savings (per annum), Rs.	Payback period, month
Water reuse in chipper house	20,000	96,000	2.5
Pressured water supply	-	-	-

digestor, extraction, and drying. During liquor washing, loss of pulp is identified as 1 %, which can be reduced to 0.6 - 0.7 % by proper in house 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.

3. 4 tpd of pulp is wasted during bleaching process as rejects in pulp plant. 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 digestors 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 in-creasing 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 the digestion time and increasing the number of batches for a day which is economically beneficial.

5. In pulp plant, sulphur is used mainly to produce sulphur dioxide which is used for preparation of calcium bisuiphite (CBS). During CBS preparation lime stone is reacted with SO, 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 stochio-metric quantities of chemicals are used for CBS preparation.

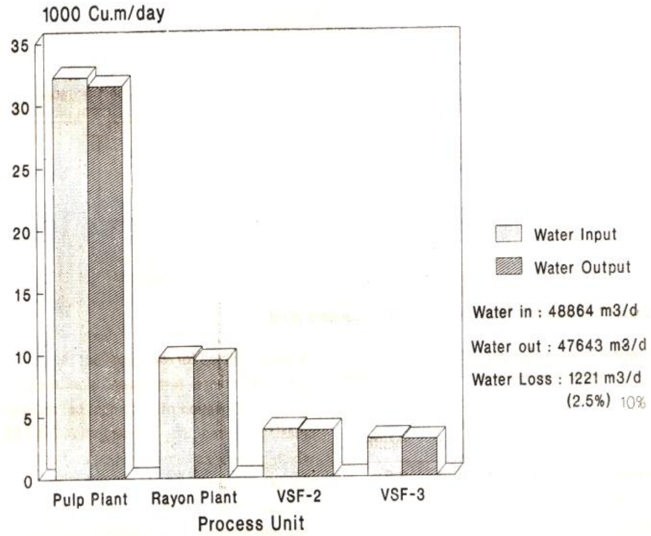


Figure 7. Water balance diagram

Figure7 Water Balance diagram

Keeping in view the process activities envisaged, size of the industry, it was decided to conduct studies on pulp process units and utilities. Available in-formation 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 disulphide.

B. Auditors' note/suggestions

1. In chipping unit, during chipping process the undersized chip pieces and the saw dust amount to about 10 kg/1000 kg of wood charged. But due to Operational problems and controlling system the waste material is not recovered through the blower system which already exists 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 he reduced to about 0.5 to 0.75 % by regularising the waste collection systems.
2. In pulp plant, about 150 tonne of pulp is produced per day. The pulp plant consists of chipper and Basic data regarding operational features and working of various process units, overall energy consumption, its cost and production figures for the last 3 year 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.

V. TRANSFORMER LOAD MANAGEMENT

1. The 2 x 1500 KVA 22 KV/41 5 V transformers in the main out door 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 transformer on the primary side in cyclic rotation of one week.
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 no. 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 : (a) Provide capacitor banks of capacity 2 MVAR on the 22 KV side at the main outdoor substation with necessary reactors, switch gear etc., (b) Operate the TG sets at an optimum power factor, that is between 0.85 and 0.9.

Replacement of over sized motors

4. Agitator motors of 30 kW rating. 7 nos. are found to be highly underloaded. It is recommended to replace these motors by 15 kW 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. Digestor circulation pump - 5, condensate pump, liquor transfer pumps 4754 and 4759 and raw ef-fluent 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 underloaded : (a) air supply fan 152/A, (b) drier fan 8353, (c) drier fan 8314, (d) air blower ETP 1, (e) air blower ETP 2, and (f) aerator no. 30.

Providing PF controllers

8. The slurry press motors 4 nos. of 30 kW each operate at low power factors and under 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 for about one and half hour in an open furnace to remove volatiles. During calcining, hot flue gases at 450 - 680 0C is vented to atmosphere without any heat recovery. The heat content of flue gas is equal to 176 kg of LP steam per hour. It is suggested to re-cover this heat by preheating W.H. boiler feed water from 30 °C to 60 °C using a heat exchanger.

Heat recovery from hot ammonia refrigerant gas

10. Chilled water for CS , plant is generated using ammonia refrigeration system. During compression, ammonia gas is heated to about 120 ()C and condensed in shell and tube condensers 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 and 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 °C for VSF 2 and 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 5 00 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 and 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 eventhough 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 °C to 70 °C in VSF 1 and from 40 0C to 70 °C in rayon bath recovery section in a heat exchanger using LP steam. About 6.75 tonne/hr of steam condensate at 90 °C is drained because of acid contamination. It is suggested to preheat the rayon spin bath from 40 00 to 46 00 in a new SS 316 heat exchanger with steam condensate and further heating upto 70 °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 00 is circulated in the tuunel dryer coils. The return hot water at 80 °C is further heated to 95 00 in a heat exchanger. The resultant steam condensate (about 1.6 tonne/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/cm2. Air is also continously leaking from the relief valve as its setting is also at 0.8 kg/cm'. 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/cm2.

Raising steam pressure in WH boiler

18. Stable fibre dryers need about 8.0 tonne of M P steam per hour at 17.0 kg/cm'. Presently MP steam is supplied from power boiler through a pres-sure reducing station, thus by passing the turbines. About 272 unit/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 temeerature from where the compressor intake air is drawn is 5 °C higher than the ambient air temperature of 31 °C. Every 4 00 increase in intake air temperature results in 1 % 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 Khosla : 2 compressor was 1E, (3C higher than the normal de-signed 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 00 rise). It is suggested to clean the intercoolers.

Heat recovery from after cooler

22.1t was observed that the Khosla compressor (sulphur burner compressor) cooling water outlet temperature was about 62 0C 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 highlighting water conservation measures.

Auditors' note/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/I of alum is being added without any jar test. Jar test should be con-ducted 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 624 rn3/day. By segregating ejecter and pump cooling water from digester house (264 m3/d) and reusing the same in chipper house flume reduces the total requirement by 360 m3/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 m3/d excluding the warm water requirement. The backwater overflow from intermediate pulp storage chest is contaminated with fibres only and hence 3100 m7day 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.
2.1n order to quantify the stack emissions, stack monitoring was carried out at steam boiler, liquor preparation section of pulp plant, VSF, rayon, H2SO4, and CS, plants.
3. Monitoring of sectional and combined waste-water discharges were carried out. Performance of evaluation of effluent treatment plant was also undertaken.
4. Work zone 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.

Auditors' note/suggestions

1. Gaseous pollutants, like SO2, and NO from pulp plant boiler stack are on higher side compared to CPCB standards. High SO2 content is due to higher sulphur content in the liquor which is used as a fuel in boiler, whereas NO and CO shows the in-complete combustion of fuel. For improved combustion techniques following measures should be adhered to : (a) Proper burner maintenance, (b) Good atomisation of liquid fuel, and (c) Provide bio - scrubbers or wet – scrubbes for controlling SO2 content in the emissions.
2. All SPM, SO2 and NO concentrations were be-low prescribed limits suggested by CPCB for industrial/mixed zones. Higher concentrations were ob-served in downwind directions.
3. Work zone monitoring results show that at 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 0.0115 m3 of air/m3 of tank to maintain the solids in suspension. So, for a tank of 9500 m3 capacity, the air flow rate should be 5700 m3/hr. Considering the capacity of existing air blowers, that is 2450 m3/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 clariflocculator. 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/I by lime precipitation alone. At present Zn concentration is 1.2 mg/l 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 tank is a must for pulp plant effluent. Total effluent from pulp section is 1300 m3/hr. Construction of pre - settling tank of 20 m x 30 m x 3 m is recommended to settled the fibrous material can settle and settled material can be sold at a rate of around Rs. 200/tonne. With this provision, frequent cleaning of equalisation tank is not necessary (presently cleaning is done 2 times in a year spending around Rs. 1.50 lakh).
10. As the existing effluent treatment plant cannot meet the stipulated standards, it is suggested to have extended aeration process which needs one settling tank after aerated lagoons I and 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/I MLSS concentration in the aerated lagoon. Excess sludge can be sent to the existing vacuum filter. With this, 95 % BOD; can be removed and zinc

concentration can be reduced to less than 1 mg/I in the final effluent. A schema-tic diagram of these modification are shown in figure 8.

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, and (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 the 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 be-fore discharging to river.

14. As extended aerated lagoon system is suggested their is no need of treating it again in aerated lagoon 111. They can directly discharge into river, Bhavani. By stopping all 7 aerators in aerated la-goon III, they can save an amount of Rs. 43,45,000 per annum.

15. Near boiler, compressor room and new 1-1,SO4 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 EPA effluent treatment plant sludge has been characterized for leachate as well as total sludge characteristics. Sludge generated from ETP falls uncle' 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 19 tonne/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.

Conservation potential

Measure	Estimated investment, Rs.	Savings (per annum), Rs.	Pay-back period, year
By providing pre clarifier for pulp plant effluent before sending the same to ETP	10,00,000	7,30,000	1.5
Reduction in cleaning frequency of equalisation tank	Nil	1,25,000	-
Discontinuation of air blowers in equalisation tank and stoppage of 7 aerators in aerated lagoons III	Nil	43,45,000	-

VIII. HEALTH AND SAFETY AUDIT

Methodology

Preliminary information (through questionnaire, protocols) on health/safety aspects was collected. Accidents through audit exercises, pre - audit meetings and inspection along with 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.

Auditors' note/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 organization, though adequate to me-et the requirements of Factories Act, does not pro-vide expertise and facilities for analysis and investigation of work area toxics. It is recommended to have a suitable person with 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 flange pa-caking 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 CS2 plant and damaged step of a ladder in rayon bleaching section can be classified under 'poor house keeping' which requires pro-per attention.

9. Wet floor and spurting of hot pulp from alkali tower causes unsafe conditions in pulp plant.

10. More stress on communication 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 an-num.

2. Secondary wastewater treatment facilities need to be improved to make the effluent conform to pre-scribed standards and ash generated in boiler hour-se 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 and VSF spin bath and acid plant waste heat boiler and it is possible to save an amount of Rs. 72. 7 lakh 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 lakh per annum. Out-come 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.