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Environmental Study of a Pulp and Paper Mill in NWFP, Pakistan

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Abstract. A detailed environmental study of a pulp and paper mill was carried out, which included effluent flow measurements and sample collection from some selected points. Stack gas analysis was carried out on the spot. The quantity of raw materials used and their wastage in the production processes were identified. The data obtained were fed into environmental balance sheets, already developed for the mill, which showed excessive use of water per ton production of paper, as compared to a European paper mill. The biological oxygen demand, chemical oxygen demand, and total soluble solids were above the permissible level of National Environmental Quality Standards specified by the Government of Pakistan. Control measures for preventing raw materials wastage, both at in-plant and end-of-pipe treatment, were recommended, which included water conservation, spill control, recovery of valuable fibre, reduction in chlorinated compounds, waste heat recovery, solid waste recovery and its safe disposal for the in-plant controls, while options for the end-of-pipe treatment were discussed with the factory management.

Keywords: pollution control, paper pulp recovery, pulp and paper mill, effluent discharge, stock gas analysis, environmental balance sheet, wastewater effluents

Introduction

Unabated environmental degradation, wasteful use of valuable resources, deteriorating ecosystems, and an appalling lack of concern for the protection of environment are among the pressing problems currently facing our country. In order to protect ourselves and future generations from the hostile polluted environment, it is only prudent to use the resources of the earth in a harmonized manner. Regulations at the national level (EPA, 1997) and international standards (ISO-14000, 1996) are in force to monitor the quality of soil, water and air within safe limits for humans, animals and other forms of lives. However, a sufficient number of reports indicate that industrial pollution in varying degrees is adversely affecting human health and ecosystems, the world-over as well as in Pakistan (GoP, 1993; WHO, 1992).

Paper and board mills in Pakistan are considered to be a source of serious industrial pollution (EPANWFP, 1997). Various environmental reports (EPA, 1997; 1996) have pointed out that the paper industry is the major river polluter in the North-Western Frontier Province (NWFP) of Pakistan. The Kabul river has been reported to be more saline due to the dumping of industrial effluents than are rivers in the USA (Khan *et al.,* 1999). It has been reported that industrial effluents have contributed to the reduction of mahseer fish (*Tor putitora*) population in this river (Muhammad, 2004). It has also been reported that the high consumption and unwise use of raw materials in the production process can be reduced at source through slight process modifications with little investment (Shah *et al.,* 2004). According to a World Bank report, the wastes of these industries can be reduced at the source by about 40% through process modifications (World Bank, 1996).

Keeping in view the principal objective of reducing waste at the source, a detailed post-environmental impact assessment study of a paper mill in NWFP was carried out. During this study, all the production stages were identified and analyzed in accordance with the methodology developed by United Nations Industries Development Organization and by using standard methods (APHA, 1998; UNIDO, 1992).

The capacity of this mill was noted to be 2800 tons of bloating paper liner per annum, working 350 days/year. The mill utilized 100% waste paper as the raw material, thus eliminating chemical pulping of wood or wheat straw or any other fibrous material. The use of deinking chemicals and bleaching agents was non-existent due to non-requirement of any colouring of the end-product. The paper-manufacturing units were established at a time when protection of environment and recycling of valuable fibres were not considered important. This has resulted in increased environmental pollution, besides financial loss to the industry.

Materials and Methods

Survey. After conducting the survey of the mill, flow diagram of the production process (Fig. 1), material balance

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sheet (Fig. 2), and water balance sheet (Fig. 3), along with the plant layout diagram indicating the selected effluent sampling points, were prepared.

Sampling. Grab effluent samples were collected from the selected sampling points into a clean 2-liter rubber container previously rinsed with the sample water. It was tightly capped, labelled and stored at 4 °C in an icebox and transferred immediately to the laboratory for further analysis. The samples were collected at different working hours of the day, thrice in a month.

Flow measurements. Flow of the effluent streams was measured by the orange-boat method (Hootsmans *et al.,* 1991). In this technique, a rough estimate of the mean velocity of a stream is determined by measuring the travel time of a floating object (paper boat in this case) along a known distance. Generally, a floating object extends from surface to about mid-depth, it travels with a velocity of about 1.0-1.1 times the mean velocity. Together with a cross-sectional area, this provides an estimate of the flow.

Analyses. Some of the parameters were analyzed on the spot, and for the rest of the analyses, samples were shifted to the laboratory immediately for further investigations.

On the spot analysis. Stack gas analysis was carried out using the instrument Enarac, model 3000 E. A small hole in the chimney was made at a height of 8 feet, and the probe of the instrument was inserted in the chimney. The observations were recorded after 30 min, as per instruction of the instrument manual. Temperature, pH and colour of the effluent were also measured on the spot.

Laboratory analysis. The priority parameters as recommended by Pakistan Environmental Protection Agency (IPI, 2000) for paper mill effluents were measured in the laboratory by applying standard methods, as recommended by Pakistan EPA (MCAIE, 2000). The biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS) and total dissolved solids (TDS) were measured by wrinkler titration, colourimetric, and gravimetric methods, respectively. The data generated were analyzed statistically (Steel and Torrie, 1960).

Results and Discussion

The analytical data of effluents discharged from four different points and their comparison with National Environmental Quality Standards (NEQS, 1993) is presented in Table 1. Pollution load was calculated by multiplying the concentration of each measured parameter with the pollution load, and the so generated data are presented in Table 2.

Comparison with the prescribed standards shows that pH (6.59) of the effluent was within the range of (6-10) of National Environmental Quality Standards (NEQS, 1993). The BOD and COD values of 220 mg/l, and 804 mg/l, respectively, were much above the NEQS values (80 mg/l and 150 mg/l). The level of total suspended solids (906 mg/l) was also well above the permissible level. However, the level of total dissolved solids of 1002 mg/l falls within the range of NEQS (3500 mg/l).

It was assessed that excessive amount of water (1728 tons/day) was being used for the production of around eight tons of paper per day. Comparison of water consumption of this

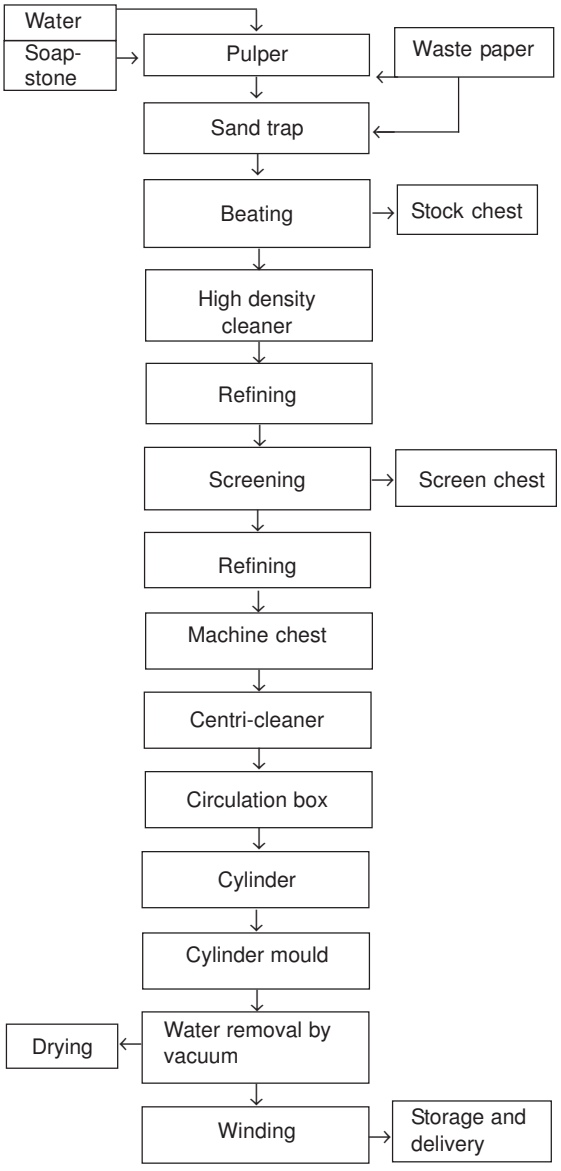

Fig. 1. Process flow diagram of the pulp and paper mill studied, NWFP, Pakistan.

mill, with the Central European paper and pulp mills showed that only 2% of the total water used was technically sufficient (RIVM, 1993).

It was determined during the survey that only a small amount of white water released from the cylinder (162.8 tons/day) was reused in the system, while the rest of the water was released into the main drain (Fig. 3). Water from the vacuum pump was discharged into the main drain as such, which should have been reused.

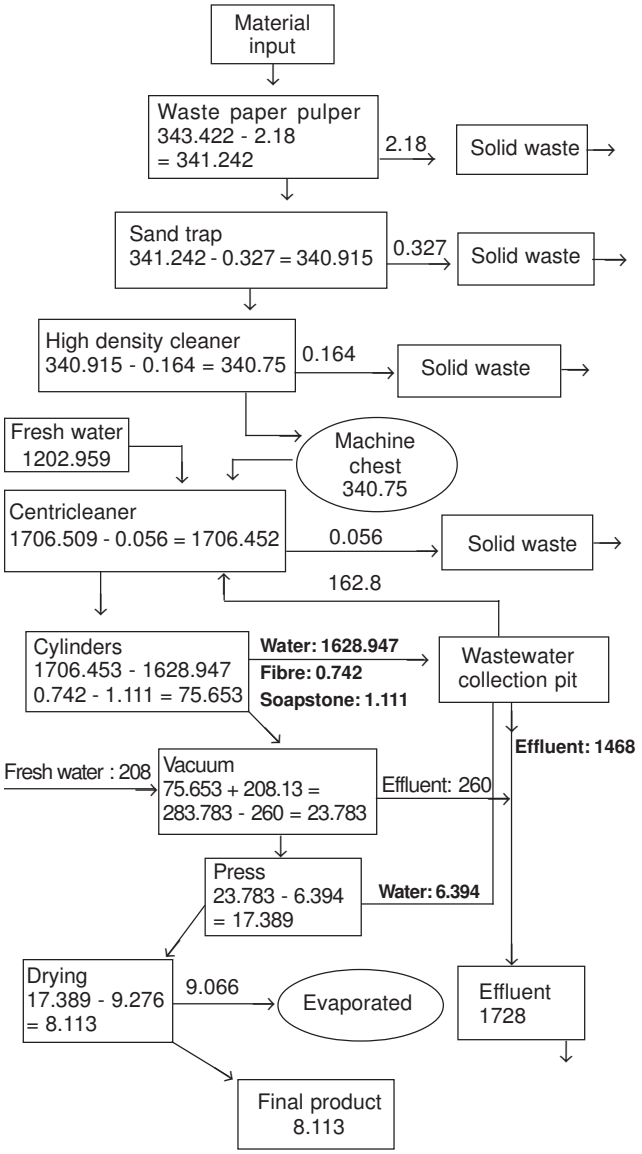

Fig. 2. Material balance sheet of the pulp and paper mill studied, NWFP, Pakistan; basis (tons/day): waste paper (10.91), fibre (7.42), contaminants (2.7), water in waste paper (2.7), soapstone (1.111), process water (331.4).

It was determined during the investigation that 10% of the valuable pulp (fibre) was lost in the effluent. This pulp material (fibres) is toxic to aquatic species as well. The colour of the effluent was brown black due to the presence of lignin. Lignin is a phenolic polymeric compound, which holds the cellulose fibres together and makes them rigid. This lignin is highly resistant to microbial attack and major part of it escapes through the conventional treatment methods, and enters into the water streams. This results in high level of BOD and COD, and is also objectionable from the aesthetic viewpoint. It also reduces phytoplankton production by restricting the transmission of light into the water.

Reduction of waste at the source and recycling of waste materials are generally better solutions in terms of improved economic and environmental benefits. Due to the economic and environmental benefits associated with waste management practices, it has been an established practice to exploit all opportunities for waste reduction or internal recycling before any investment in the end-of-pipe treatment is made.

In-plant control measures for effluent waste reduction include installation of a Kraft process (effective fibre recovery system) by making minor investment. Fibre recovery may be carried out within the mill premises, thus improving the mill profits, besides reducing BOD and COD loads, and the end-of-pipe treatment cost.

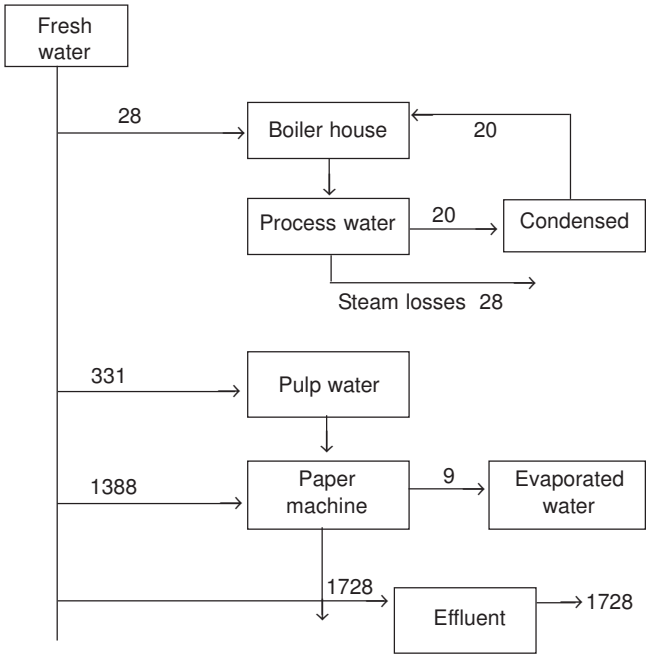

Fig. 3. Water balance sheet of the pulp and paper mill studied, NWFP, Pakistan; basis: m^3/day.

The extravagant use of underground water can be reduced by installing water flow meters on the consumption pipelines, automatic shut-off valves, shutting down of water supply when not required and recycling of water at all possible points, and monitoring and follow up of automatic shut-down procedures for the water turbines when pulping or paper machine sections are out of production. Recovery and recycling of clean water from the vacuum pumps is also recommended (Fig. 2).

The biological wastewater treatment plant for the treatment of the mill effluents is recommended at the end-of-pipe, as major part of lignin escapes undecomposed in the conventional treatment plant. However, to make it economical, it is important to reduce the volume of wastewater by reusing the water of the uncontaminated or less contaminated section of the pulp and paper mill.

Gaseous emissions are shown in Table 3. Natural gas was the only major source of energy and all the measured parameters were within the NEQS limit (NEQS, 1993). Air pollution did not pose any environmental problem from this pulp and paper mill.

Solid wastes being generated from the mills are in the range of 30-40 kg/day. The wastes contained unpulpable, non-fibrous material, such as plastic, polymer-coated paper, and glass, bone, small stone and metal pieces. It is recommended to sell out the recyclable material to other industries in the area, while the rest is to be dumped in the low lying areas of the mills as earth-fill.

Poor occupational health and safety working environment was another area of concern. It is recommended that regular training and education on safety and provision of safety equipment is ensured to the workers of the mills.

Table 1. Measured pollution load of untreated effluents from the pulp and paper machine section

Parameters	Values determined	National Environmental* Quality Standards
Flow (m^3/day)	1728	
pH	6.59	6-7
BOD_5 (mg/l)	220	80
COD (mg/l)	804	150
TDS (mg/l)	1002	3500
TSS (mg/l)	906	150

*NEQS (1993); BOD_5 = biological oxygen demand; COD = chemical oxygen demand; TDS = total dissolved solids; TSS = total soluble solids

Table 2. Pollution load of untreated effluents from the pulp and paper machine section

Parameters	Values determined
Flow (m^3/day)	1728
BOD_5 (tons /day)	380
COD (tons/day	1389
TDS (tons/day)	1731
TSS (tons / day)	1565

BOD_5 = biological oxygen demand; COD = chemical oxygen demend; TDS = total dissolved solids; TSS = total soluble solids

Table 3. Emission of gases of the pulp and paper mills, using gas-based boiler

Parameters	Values determined (mg/Nm^3)
Particular matter	< 300
Hydrogen sulfide	< 10
Sulfur dioxide	< 400
Nitrogen oxides	< 400
Carbon monoxide	< 400

Conclusion

It is concluded that high concentrations of biological oxygen demand, chemical oxygen demand, total dissolved solids, loss of valuable pulp (about 10% fibre), extra amount of water consumption, generation of solid waste and poor occupational health and safety practices were the major problems of the pulp and paper mill studied for environmental status. The recommended in-plant control measures and recycling of pulp from the effluents, will not only enhance net profit of the mill but will also reduce end-of-pipe treatment cost. Beside, the mill will have to achieve national and international environmental quality standards. The present report is documented with a view that other similar industries will benefit from the findings of this study.

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