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Environmental Problems and their Control Measures of a Glass Factory at Peshawar (Pakistan)

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Detailed environmental survey/audit of a glass factory was carried out. Balanced sheets for raw materials and water consumption were prepared. Environmental problems especially associated with the unwise use of raw materials were identified and waste minimization techniques at source as well as at the end of pipe treatment were suggested. With the implementation of these techniques, the industry improved its production and achieved the national and international environmental quality standards.

Key words**:** Environment survey/Audit of industry, Balance sheet, Air and water pollution control.

Introduction

Industrialization is touching almost every corner of the country, bringing with it economic benefits. Simultaneously environmental problems are also emerging due to irresponsible and indiscriminate use of chemicals in these factories (IPI 2000). These chemicals when reach to the environment exert significant adverse impacts in terms of aesthetic, economy and ecology. Inorganic salts present in the industrial waste water become hard and make a stream undesirable for industrial, municipal and agricultural usage (WHO 1972). Acids and alkalis make a stream unsuitable for recreational use (De 1986). Moreover, wide variety of organic matters present in these wastes exhaust the oxygen resources of receiving water bodies, create unpleasant tastes, odor and affect fish and other aquatic life (Vogel 1978).

Both domestic and industrial wastewaters in Pakistan are discharged untreated into water bodies, which pollute even the underground potable water (Khan *et al* 1999a; Khan *et al* 2000; Akif *et al* 2002). This damage can be regarded as long lasting and irreparable. Previously, it has been reported (Khan *et al* 2000; Khan *et al* 1999b) that the underground water quality at these places has been deteriorated resulting in increase in the water-borne diseases among the end users.

Due to continued discharge of industrial effluents, the Kabul River water quality at Amangarh, Nowshera, which is about 70 km downstream to the Warsak Dam was badly affected. The industrial effluents contributed in reducing the population of fish Mahaseer *Tor putitora* (Muhammad 2004). Besides, the Kabul River has been reported to be more saline due to dumping of industrial effluents than the rivers in USA (Khan *et al* 1999a).

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It has been estimated (Beg *et al* 1985), that only Karachi Harbor receives total dissolved solids of the order of 376.2 metric tons, Calcium bicarbonate 162.0 metric tons, chloride 152.4 metric tons, sulfate 151.74 metric tons, calcium carbonate 115.74 metric tons, Magnesium oxide 60.0 metric tons, organic matter in TDS 47.34 metric tons and suspended solid 34.2 metric tons. The same workers also mentioned that the suspended matters reached the coast at an average rate of 30 tons per day.

The study (GOP 1993) reveals that a number of industries in the North West Frontier Province (NWFP) of Pakistan are discharging effluents with high concentration of pollutants varying from toxic metals and metal salts to bacteria, acids and oils (Table 1 & 2).

The pollutants load (Table 1 & 2) indicate a high consumption and unwise use of raw materials in the production process, which can be reduced at source by slightly process modification and with less investment. According to the UNEP survey reports (UNEP 1982), about 40 % of industrial pollutants load in the developing countries could be reduced at the source, which would also reduce end of pipe treatment cost.

Keeping in view the objective of reducing waste at the source, a detailed environmental study of a glass factory was carried out by using the UNEP environmental audit guidelines and pollution control measures were recommended accordingly.

Experimental

Survey. A detailed environmental survey of the mill and production process was carried out. Flow diagram of production process (Fig 1), material balance sheet (Fig 2) and water balance sheet (Fig 3) along with plant layout diagram (Fig 4), indicating effluent sampling points were prepared.

Table 1
Pollution load in effluent of sample industries at Peshawar

S. No.	Name of the industry	Discharge m.g.d	Temp. (°C)	Color	pH	S.S mg/l	BOD mg O_2/l	Ibs.BOD per day	Toxic metals
1.	Sarhad fruit and veg. Industry	Nominal	23	25	6.9	428	509	-	-
2.	Khazana sugar mill	2.5	25	35	6.7	960	31	642	ND
3.	Makk Beverages and Minerals	0.67	21	20	8.7	392	46	260	25 mg/l
4.	New Frontier Punjab Tanneries	0.38	23	65	6.1	4060	767	8794	ND

Source; GOP, 1993c

Table 2
Pollution load in effluent of sample industries at Nowshera

S. No.	Name of the industry	Discharge m.g.d	Temp. (°C)	Color	pH	S.S mg/l	BOD mg O_2/l	Ibs.BOD per day	Toxic metals mg/l
1.	Associated Industries LTD	4.06	35	35.0	7.5	844	143	2404	ND
2.	Colony Sarhad Textile mills	0.12	42	20.0	11.7	5828	485	485	ND
3.	Adamjee paper and board mills	4.50	27	6.5	6.7	21113	930	34900	ND
4.	SDA Leather factory	0.001	30	30.0	7.6	1692	839	11	Cr 0.53
5.	Adamjee chemical factory	0.90	26	25.0	2.0	4040	1021	7664	ND

Source; GOP, 1993

Table 3
Average measured pollution level of untreated effluent from the glass factory

S. No.	Effluent sample	Flow m^3/day	No. of samples	pH	BOD_5 mg O_2/l	COD mg O_2/l collected	TSS mg/l	TDS mg/l	Oil & grease mg/l
1.	Machine cooling (MC)	254.0	3	8.3	10	17	136	350	ND
2.	Effluent after cullet washing (CW)	290.5	3	11.0	72	140	442	2000	700
3.	First silica washing (1st SW)	52.0	3	6.2	250	540	1102	280	ND
4.	Second silica washing (2nd SW)	76.0	3	8.0	220	410	3900	325	ND
5.	Main Drain (MD)	440.5	3	8.2	400	700	600	335	ND
6.	National Environmental Quality Standards (NEQS)			6-10	80	150	150	3,500	10

Sampling. Grab effluent samples were collected from the sampling points (Fig 4) into a clean 2-litre 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 taken at different working hours of the day, three times a month.

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

Analysis. On the spot analysis. Air pollution at the main stack combustion chamber (Sampling point Fig 4) were measured (Table 5) by using Enarac model 3000, instrument. At a height of 8 feet, a small hole in the chimney was created and the probe of the instrument was inserted inside the chimney. The results were recorded after 30 min measurements. Tem-

Table 4
Average measured pollution load of untreated effluent from the glass factory

S. No.	Effluent sample	Flow m^3/day	No. of samples collected	BOD_5 mg/l	COD mg/l	TSS mg/l	TDS mg/l	Oil & grease mg/l
1.	Machine cooling (MC)	254	3	2540	4318	34544	88900	ND
2.	Effluent after cullet washing (CW)	290.5	3	20916	40670	128401	58100	203350
3.	First silica washing (1st SW)	52	3	13000	28080	57304	14560	ND
4.	Second silica washing (2nd SW)	76	3	16720	31160	296400	24700	ND
5.	Main Drain (MD)	440.5	3	176200	308350	264300	147567.5	ND

perature, pH, color of the effluent were also measured on the spot by ordinary thermometer, pH meter and other observations respectively.

Laboratory analysis. All the priority parameters recommended by Pak EPA (IPI-2000) for the glass factory were measured in the laboratory by applying ASTM (ASTM 1980) and Pak-EPA (IPI 2000) standard methods. The BOD_5, COD, TSS and TDS were measured by winkler azide titration method, colorimetric, and gravimetric methods respectively. Oil and grease were measured by using gravimetric separator funnel extraction technique (IPI 2000). All the data generated were analyzed statistically (Steel and Torrie 1960).

Results and Discussion

The analytical data of effluent discharged from four different points are presented in Table 3. The effluent at sampling point MC (Machine Cooling) consists of water that overflows from the machine cooling pond when fresh water is added for cooling purpose. The analytical results of the measured parameters i.e. PH (7.82), BOD (10 mg/l), COD (17 mg/l), TSS (36 mg/l) and TDS (350 mg/l) fall within the Pakistan National Environmental Quality Standards (NEQS 1993), the comparison shown in Fig 5. The effluent at point CW (Cullet Washing with sodium carbonate and water of the compressor cooling) has pH 11, TSS 442 mg/l, above the permissible level of NEQS (NEQS 1993). The level of oil and grease is also quite higher than the permissible level of 10 mg/l.

The raw material, silica is washed at two stages. In the first stage fine dust particles and in the 2nd stage undersized silica are removed from the main bulk. At the stage of first silica washing (1st SW) the effluent shows concentrations of BOD 250 mg/l, COD 540 mg/l and TSS 1102 mg/l, above the permissible levels (comparison Fig 5). At the sampling point of second silica washing (2nd SW), the concentrations of BOD, COD and TSS are 220 mg/l, 410 mg/l and 3400 mg/l respectively, which are also above the NEQS levels (NEQS 1993).

Table 5
Results of air emissions from the glass factory

Parameters	NEQS (mg/Nm^3)	Concentrations
Hydrogen sulfide	10	Nil
Carbon monoxide	800	Nil
Sulfur dioxide	400	Nil
Oxides of nitrogen	400	73
Smoke point	40 % on Ringleman scale	2 Equal to 40 % on Ringleman scale
Lead	50	Nil
Zinc	200	Nil
Cadmium	20	Nil
Copper	50	Nil
Arsenic	20	Nil
Antimony	20	Nil
Mercury	10	Nil

Note (Boiler combustion mode is natural gas)

Effluent of the Main Drain (MD), consists of wastewater from all sections of the factory (Table 3) except the 1st SW, where wastewater is discharged directly to the main drain (Fig 4). The concentrations of BOD, COD and TSS at this point are 400 mg/l, 700 mg/l and 600 mg/l, respectively and are above the permissible levels of NEQS (Comparison Fig 5).

Excessive amount of fresh water is used in the mill to dilute the concentrations of pollutants. Therefore, the average results of pollutant concentrations are converted to pollution load, by multiplying it with the flow rate. The average pollution load is presented in Table 4.

Air pollution (Natural gas is burned in the furnace) from the mill is not posing an environment problem, as all the parameters (Table 5) are within NEQS levels (NEQS 1993). However, particulate matters that vaporize from the glass furnace and condense at a lower temperature pose a health hazard problem for the workers working inside the main production hall.

The workers require dust masks, air muffs for noise pollution control. Besides, rotation of workers, reduction in working hours and regular medical check up are also necessary to pre-vent the occurrence of occupational diseases.

The solid waste of the mill consists of broken glass, called cullets, and unsized silica particles. Landfill disposal technique is recommended in the low laying areas of the factory.

The in-plant control measures for removal of oil and grease at point CW, is the installation of centrifugation, plain floatation or dissolved air floatation technique. The recovered oil through this method could be used for lubrication.

The suspended and dissolved solids at point 1st SW and 2nd SW could be removed by installing settling tanks and their sludge are to be used as landfill in the low laying areas of the mill.

As discussed earlier, that excessive amount of fresh waters i.e. 288 m^3/day water is used as an extra for cooling the air compressor and machines. Installing a small cooling tower at point

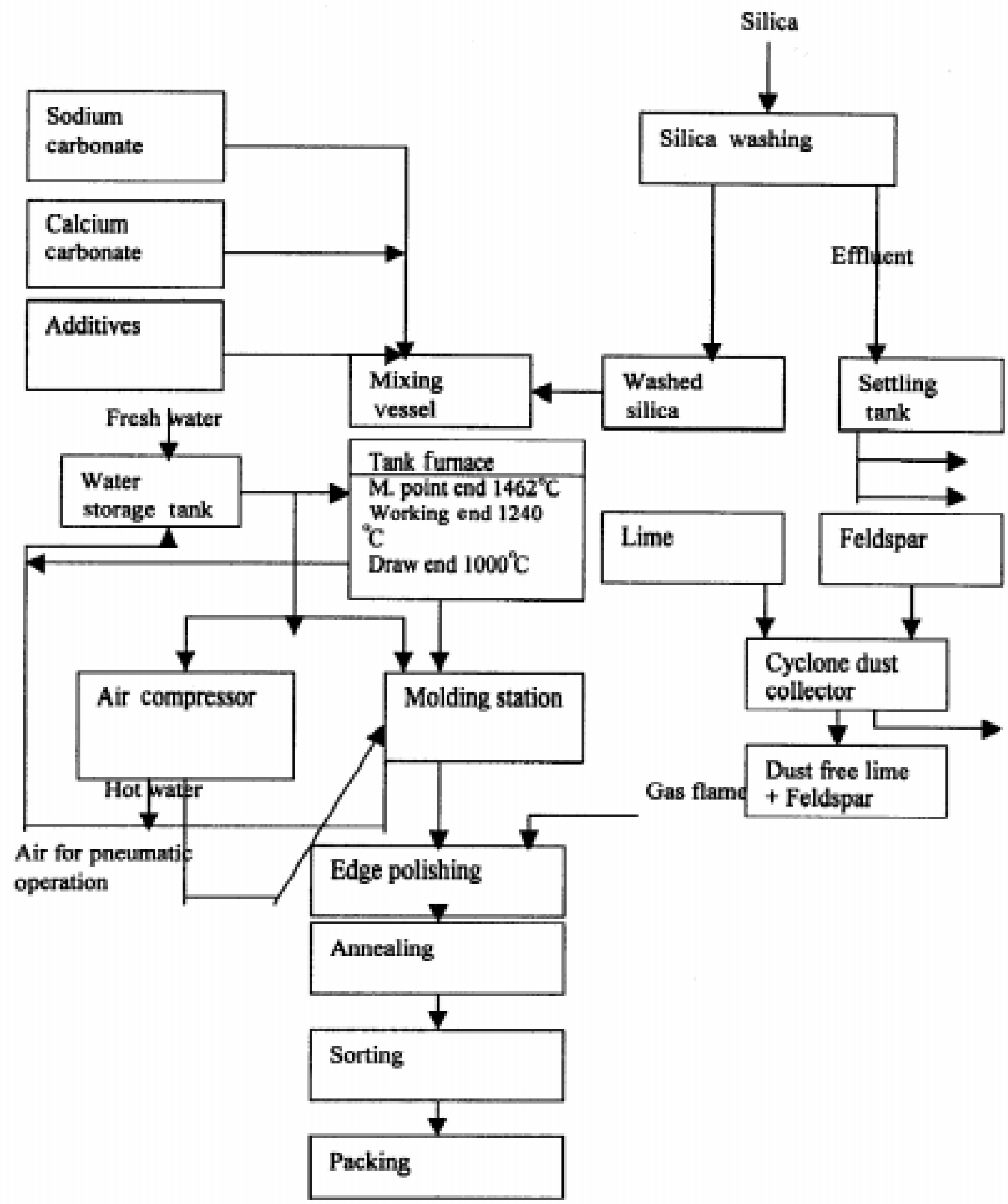
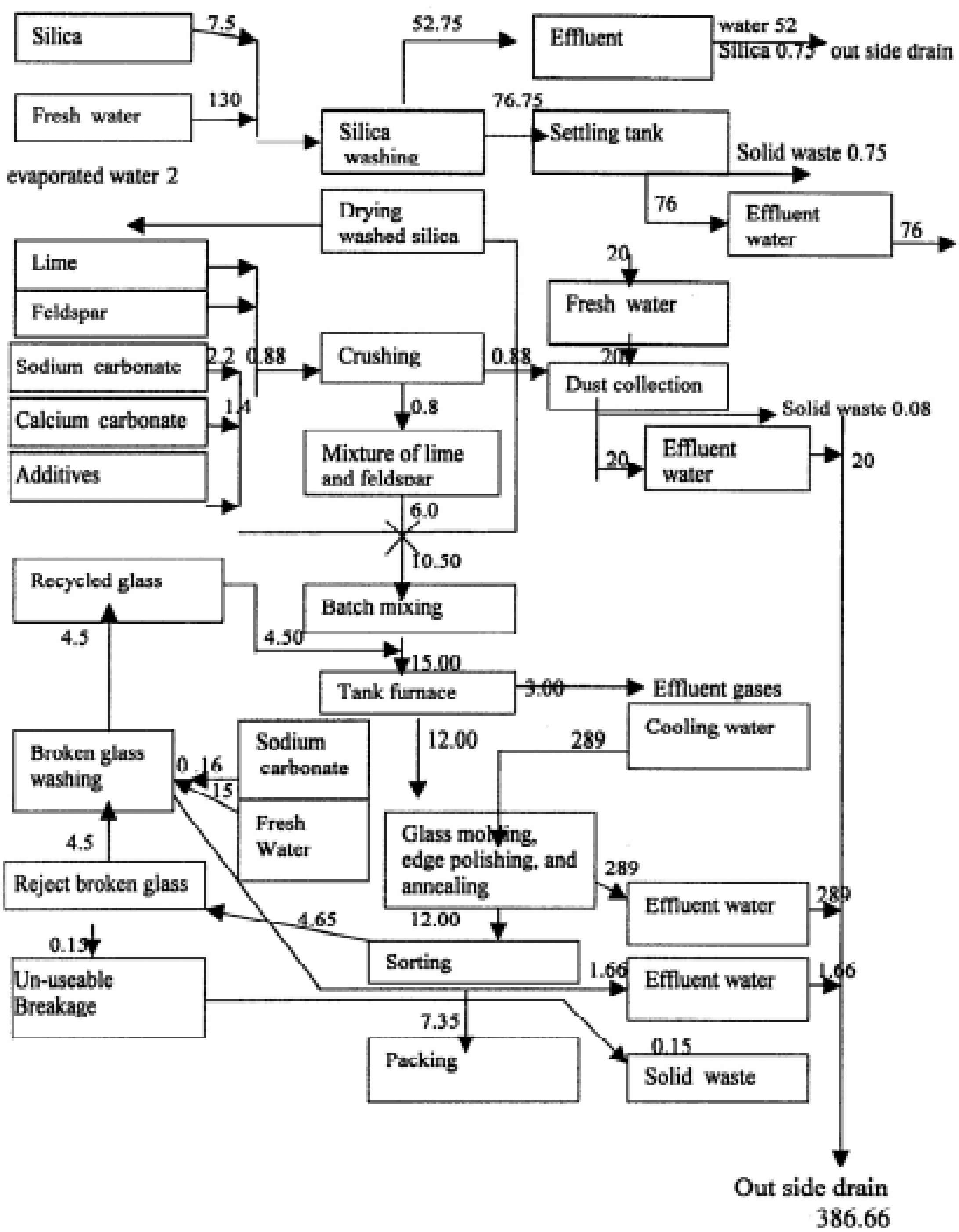


Fig 1. Process flow diagram.

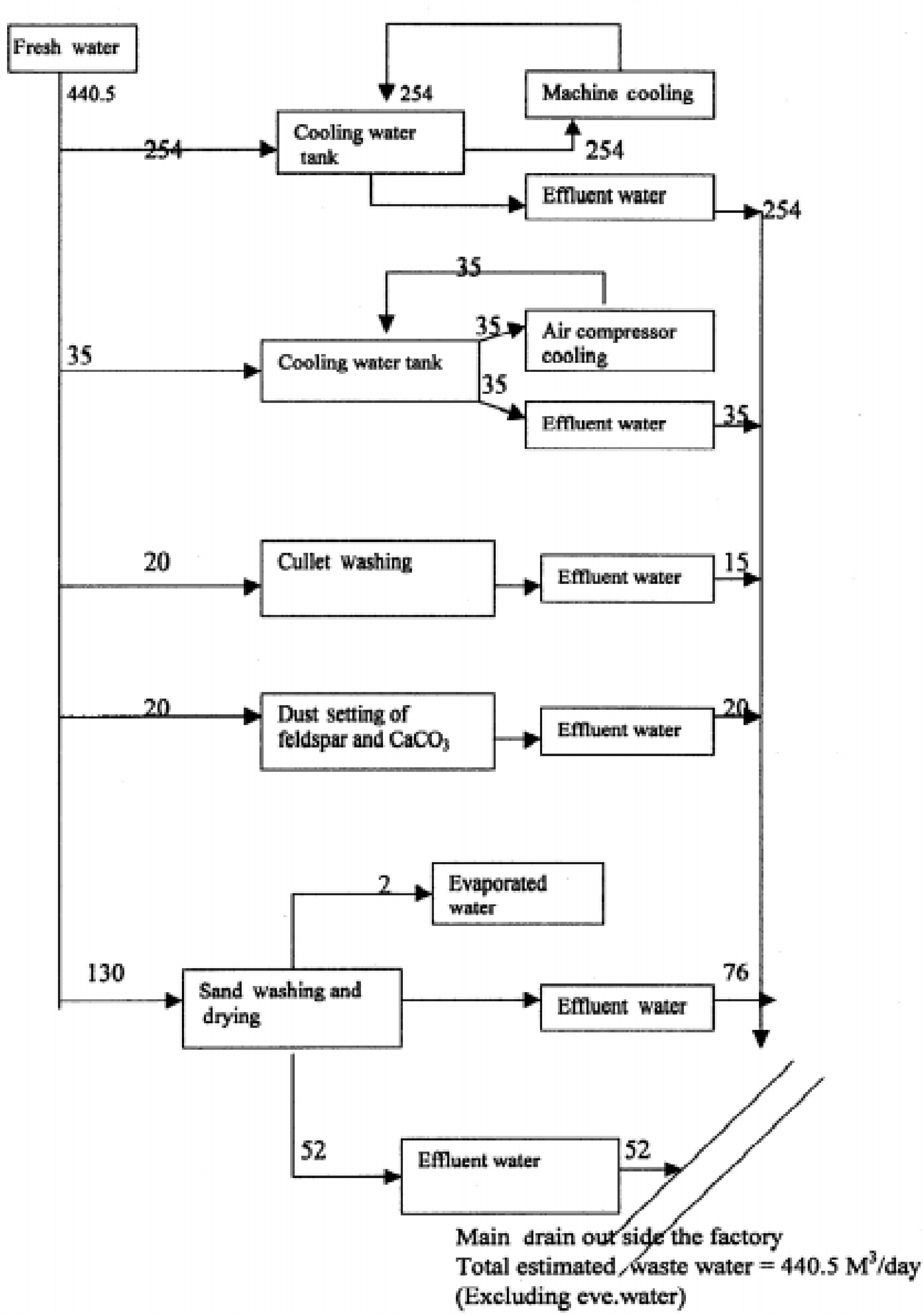
CM (Fig 4) could save this water. Besides, it would reduce the cost of end of pipe treatment.

Pollution load of BOD and COD in the main drain of the glass industry reveal that, with the implementation of the above in-plant control measures and the employment of appropriate settling tanks, the potential of biological treatment for the waste water would still exist but would be reduced appreciably, if not completely eliminated.



Basis; Tons/day

Fig 2. Material balance sheet.



Basis; m³/day

Fig 3. Water balance sheet.

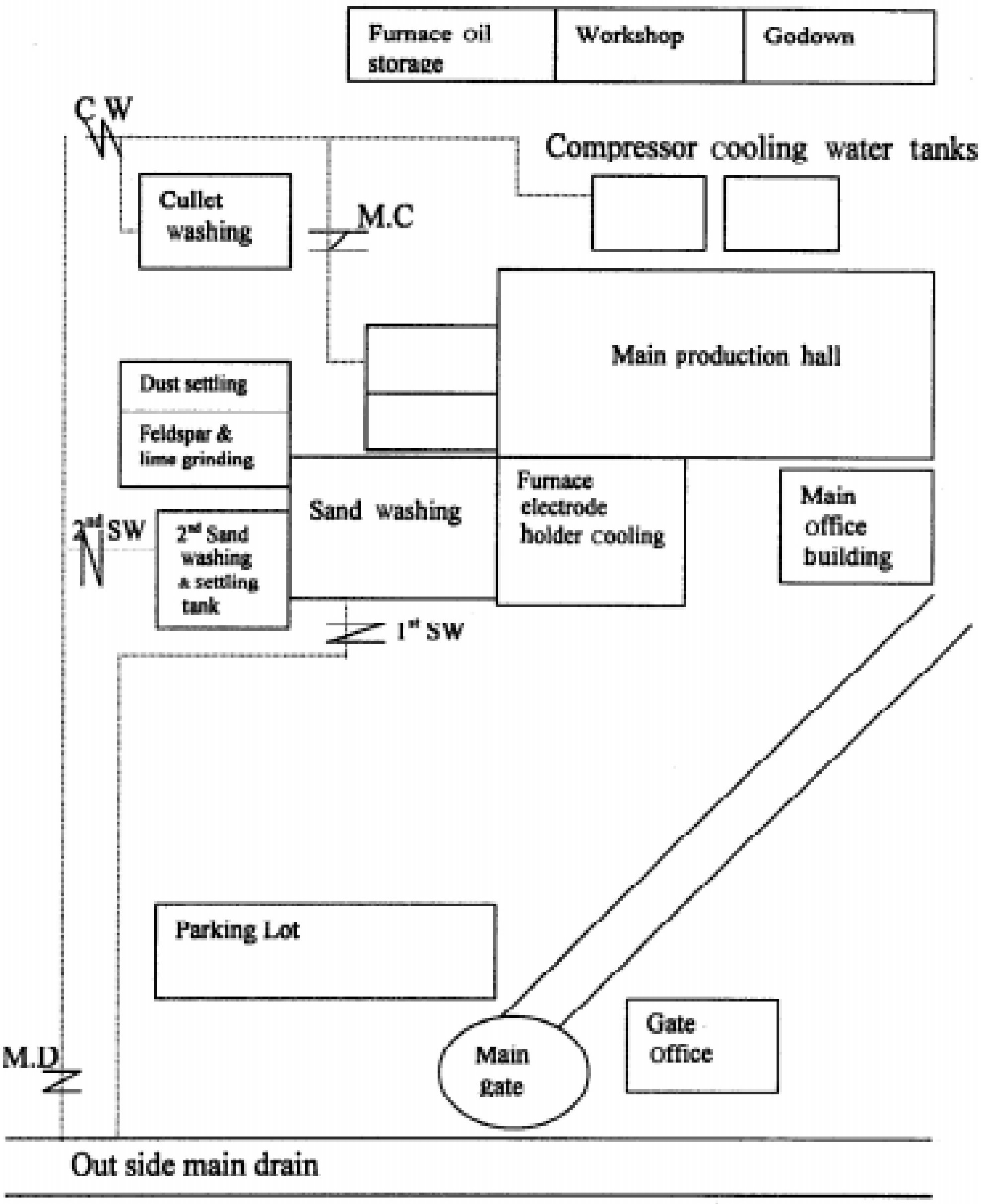


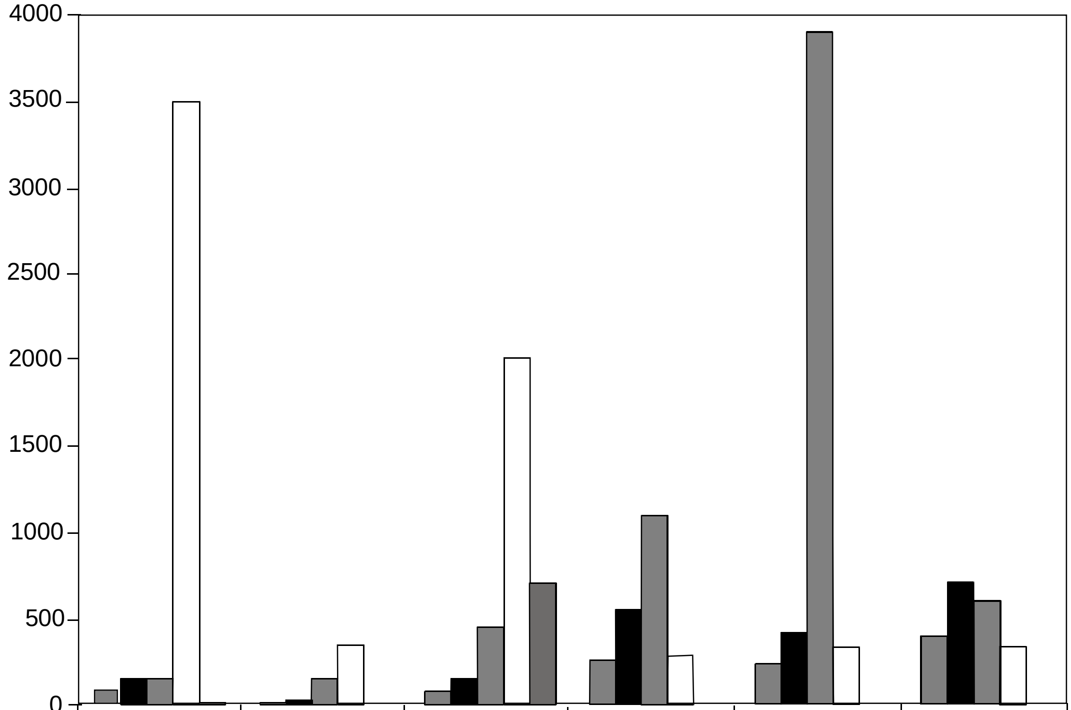
Fig 4. Plant layout diagram indicating sampling points.

The present study shows that unwise and excessive amount of raw material is used during production process. This is not only affecting the environment quality but also causing financial loss to the industrialist. The suggested in-plant and end of pipe treatment techniques if properly implemented will not only improve the business but national and international environment quality standards will be achieved with the least cost. This work would be useful for other similar nature of industries.

Conclusion

This paper carries out environmental survey/audit of a glass factory at Peshawar (Pakistan). The results suggest that lack of knowledge among factory owners; the raw materials are used un-wisely. Instead of employing waste minimization techniques both at source and end of the pipe, the pollutants are diluted which contribute towards increase in the overall expenses of the process.

This paper advises recommendations on waste minimization in the factory. The suggested pollution control measures, if employed, will not only reduce the end of pipe treatment cost, but will also save the cost incurred on raw material. Due to cost effective practices as recommended, the factory will achieve the national and international environmental quality standards.



	NEQS	MC	CW	1SW	2nd SW	MD
Series1	80	10	72	250	220	400
Series2	150	17	140	540	410	700
Series3	150	136	442	1102	3900	600
Series4	3500	350	2000	280	325	335
Series5	10	0	700	0	0	0

Fig 5. Comparison of the results with National Environmental Quality Standards.

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