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Wastewater Reuse : Problems & Prospects

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Abstract : *The need for waste water reuse has been recognised for many years as crucial to our developmental aspirations but till recently very mearge systematic endeavour has been made except for traditional use of sewage for sewage farming in arid or semi-arid areas and the use of reclaimed waste water for industrial cooling purposes. The R and D activities in India have demonstrated that waste water is a misplaced resource and its management through innovative indegenous technology, fully exploiting the advantages that nature has bestowed on the country, could result in productive propositions. Cost effective technology is available today for the reuse of municipal and industrial waste water for industrial and agricultural requirements. A few such case studies have been presented in this paper.*

1. Introduction

The galloping population pressures and rapid industrialization have rendered water to the class of scarce natural resource in India. The solution to this problem warrants planned reuse of wastewater for various designated water usages such as agriculture, industrial, recreational and fire fighting. The need for wastewater reuse has been recognized for many years as crucial to our developmental aspirations but till recently very mearge systematic endeavour has been made except for traditional use of sewage for sewage farming in arid or semi-arid areas and the use of reclaimed wastewater for Industrial cooling purposes. The situation is now showing a favourable trend as evidenced by such initiatives as the possibility of a legislation on waste recycling (1). This is largely due to disturbances in water cycle and consequent increase in tarrifs for municipal and industrial water.

The R & D activities in India have demonstrated that wastewater is a misplaced resource and its management through innovative indegenous technology, fully exploiting the advantages that nature has bestowed on the country, could result in productive propositions. Cost effective technology is available today for the reuse of municipal and industrial wastewater for industrial and agricultural requirements. A few such case studies have been presented in this paper.

It is essential to differentiate between water reuse and recycle. While reuse refers to the utilization of water that has been used previously for another purpose, recycle is the reuse of water one or more times for the same purpose. The viable routes for municipal and industrial water reuse and recycling are shown in Figs. 1 & 2.

2. Reuse of Municipal Wastewater

Municipal wastewater contains organic matter that is easily biodegradable but significant load of pathogenic organisms limit its reuse potential. The general characteristics of wastewater after biological treatment are delineated in Table 1 (2).

The conventional treatment for municipal wastewater comprises preliminary treatment in the form of screening and grit removal, primary sedimentation, and secondary biological treatment. The efficiencies for the various treatment options are presented in Table 2 (3).

Though use of municipal wastewater without treatment for irrigation is not uncommon, the associated health risks warrant use of treated wastewater while restricting the crops to cereals, pulses, potatoes and others which are cooked before consumption. The treated wastewater application rates for some sewage farms in India are presented in Table 3 (4). Recommended crops for various levels of municipal wastewater treatment are listed in Table 4 (4).

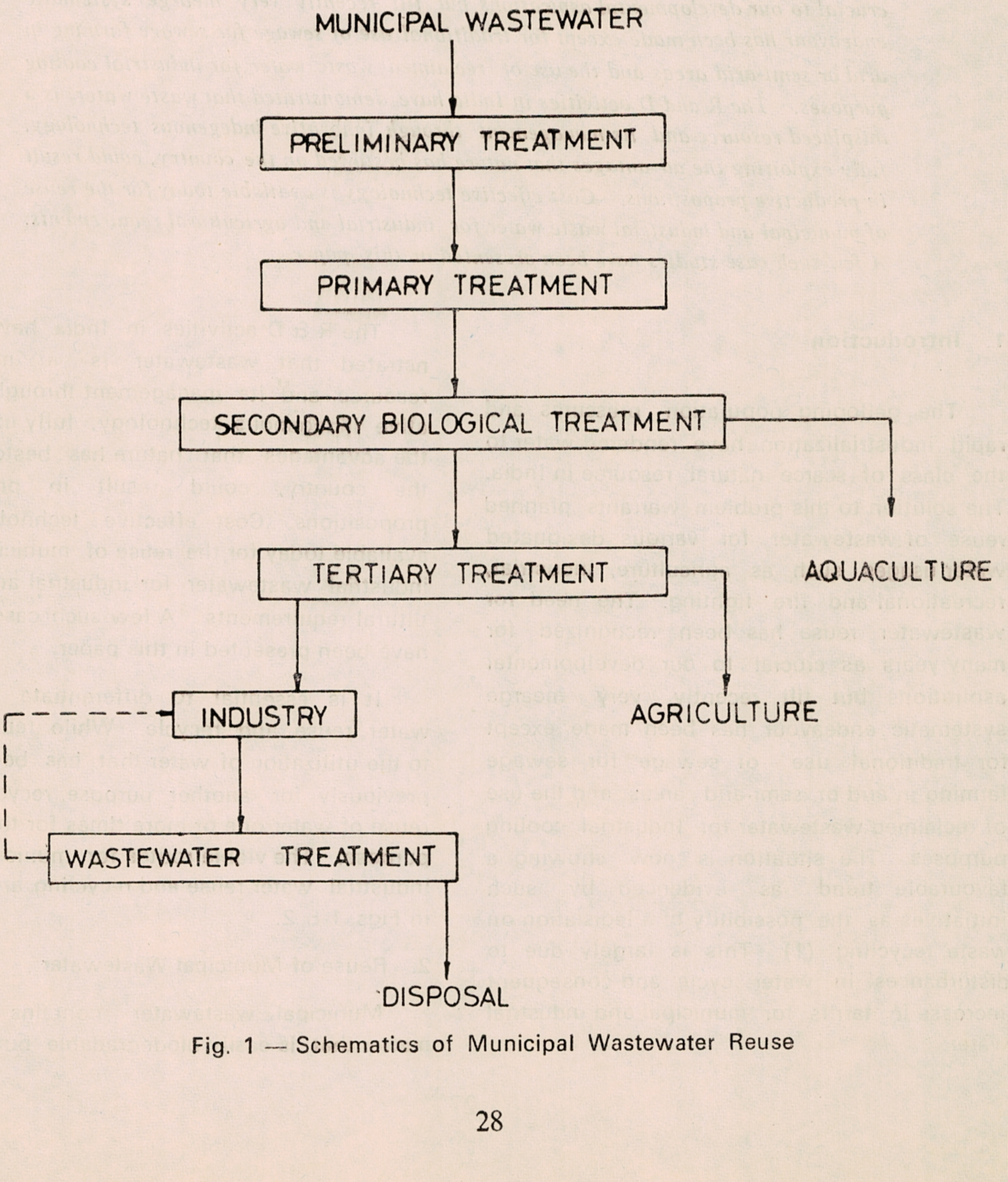

Fig. 1 — Schematics of Municipal Wastewater Reuse

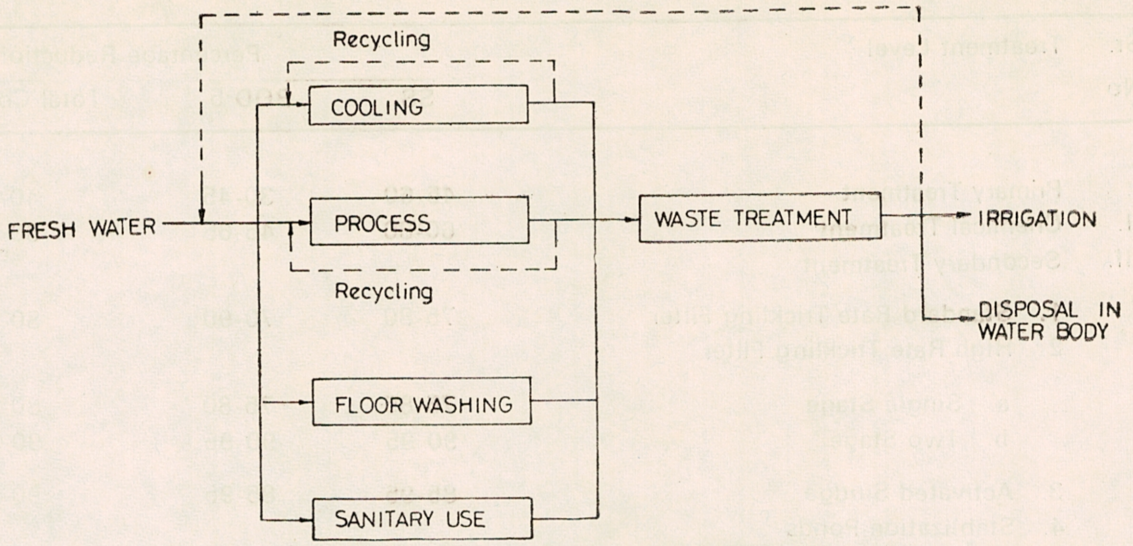

Fig. 2 — Schematics of Industrial Wastewater Recycling

TABLE 1 : CHARACTERISTICS OF BIOLOGICALLY TREATED SEWAGE

Sr. No.	Constituents	Range (mg/l)	Typical value (mg/l)
1.	Suspended solids	13-62	25
2.	BOD, 5 days at 20 °C	13-75	25
3.	Chemical Oxygen Demand	50-160	70
4.	Total N	10-25	20
5.	Total P		10
6.	Cadmium		0.015
7.	Chromium	.02-.14	
8.	Cobalt	.05-.14	
9.	Copper	.07-.14	
10.	Iron	.10-.43	
11.	Lead	.10-.03	
12.	Manganese		.2
13.	Mercury	.0001-.125	.001
14.	Nickel	.03-.02	
15.	Zinc	.2-.44	
16.	Boron		1.0
17.	Calcium	1-40	20
18.	Magnesium	1-10	17
19.	Potassium	7-10	
20.	Sodium	40-100	
21.	Chloride	40-100	
22.	Sulphate	12-52	
23.	Oil	0-10	
24.	Phenol	0-1	

TABLE 2 : PERFORMANCE DATA FOR WASTEWATER TREATMENT UNITS

Sr. No.	Treatment Level	Percentage Reduction		
		SS	BOD 5	Total Colifroms
I.	Primary Treatment	45-60	30-45	40-60
II.	Chemical Treatment	60-80	45-65	60-90
III.	Secondary Treatment			
	1. Standard Rate Trickling Filter	75-80	70-90	80-90
	2. High Rate Trickling Filter			
	a. Single Stage	75-85	75-80	80-90
	b. Two Stage	90 95	90-95	90-96
	3. Activated Sludge	85-95	85-95	90-96
	4. Stablization Ponds			
	a. Single Cell	80-90	90-95	90-95
	b. Two Cell	90-95	95-97	95-98
	5. Aerated Lagoon	80-90	80-90	90-95
	6. Oxidation/Carrousel Ditch	80-90	90-98	90-95

A major reuse potential of municipal waste water relates to its utilization in industries. The salient benefits of reuse of domestic wastewater for industrial purposes include uniform composition, dependable flow and, in many situations, less expensive water resource compared to municipal water supply. The treatment flowsheet for rendering domestic wastewater fit for reuse is depicted in Fig. 3. The cost of water production for various designated usages are compared in Table 5. The cost benefit analysis for reuse of municipal wastewater for industrial application is summarised in Table 5 (5, 6).

3. Recycling of Industrial Wastewater

The approach of industries towards pollution control, thus far, has been restricted to end-of-pipe treatment to meet stipulated effluent standards. A shift in approach to water quality management is desirable in view of options of modifications in input, low and non waste technologies (LNWT) of production & modifications in product in keeping with the an integrated approach to water pollution control presented in Fig. 4 (7). Possible avenues for waste volume reduction through process modification in some industries are summarized in Table 6.

In many situations where non-availability of water forces curtailment of industrial production in summer, a waste management scheme resulting in the recycle of treated wastewater would encourage initial investment in treatment that could be recovered in course of time.

A treatment flowsheet for wastewater recycle in apparel industry is presented in Fig. 5 (8). The treatment process essentially comprises equalization, chemical coagulation and flocculation, clarification, pressure filtration, fluidized bed activated carbon adsorption

TABLE 3 : SALIENT FEATURES OF IMPORTANT SEWAGE FARMS

Sr. No.	Location of farm	Area, acres	Nature of effluent	Sewage used	Dilution water	Major soil type	Dosage, gpad	Major crops cultivated
1.	Bhilai	1500	Treated (Stabilization pond)	8	Nil	Sandy loam, clay-loam	4,000-8,000	Paddy, maize, guar, wheat and vegetables
2.	Gwalior	500	Raw	2.5	Nil	Silt loam, clay-loam	5,000-20,000	Paddy, maize, guar, jowar, cowpea wheat, potato, berseem and vegetables
3.	Madras	330	Raw	1.5	Nil	Sandy to silt loam	5,000-7,000	Para grass
4.	Madurai	190	Raw	3.0	Nil	Red sandy loam	10,000-17,000	Guinea grass
5.	Trivandrum	92	Raw	1.9	0.5	Sand	40,000-80,000	Para grass
6.	Kanpur	3500	Raw	7.0	7.0	Loam, silt loam	5,000-10,000	Wheat, paddy, maize, barley, potato, otas vegetables
7.	Jamshedpur	280	Treated (Secondary)	2.0	Nil	Clay loam	4,000-5,000	Napier, para and guinea grasses, berseem, jowar and maize

TABLE 4 : RECOMMENDED CROPS FOR SEWAGE FARMING

Sr. No.	Type of sewage effluent	Recommended crops (in order of preference)
1.	Raw Sewage (preferably diluted)	a. Commercial crops e.g. cotton, jute milling type sugarcane, cigarette tobacco,
		b. Essential oil bearing crops e.g. citronella, mentha, lemon grass
		c. Any crop raised exclusively for seed production
		d. Cereal & pulse crops with well protected grains e.g. wheat, paddy moong, arhar
		e. Oil seeds e.g. linseed, castor, mustard, sunflower, soyabean
		f. Fruit crops (well protected e.g. cocounut, banana, citrus, etc.
2.	Primary treated sewage (preferably diluted)	a. to f as above
		g. vegetables exclusively cooked before eating and borne away from the soil, e.g. brinjal, ladysfinger, cucurbits, beans etc.
		h. Fruit crops borne sufficiently away from the soil. e.g. guave, chikoo, grape, papaya, mango
3.	Secondary treated	a. to h as above
		i. All types of crops including vegetables borne near the soil surface but eaten after cooking
4.	Secondary treated and disinfected sewage	a. to i as above
		j. All crops without restriction

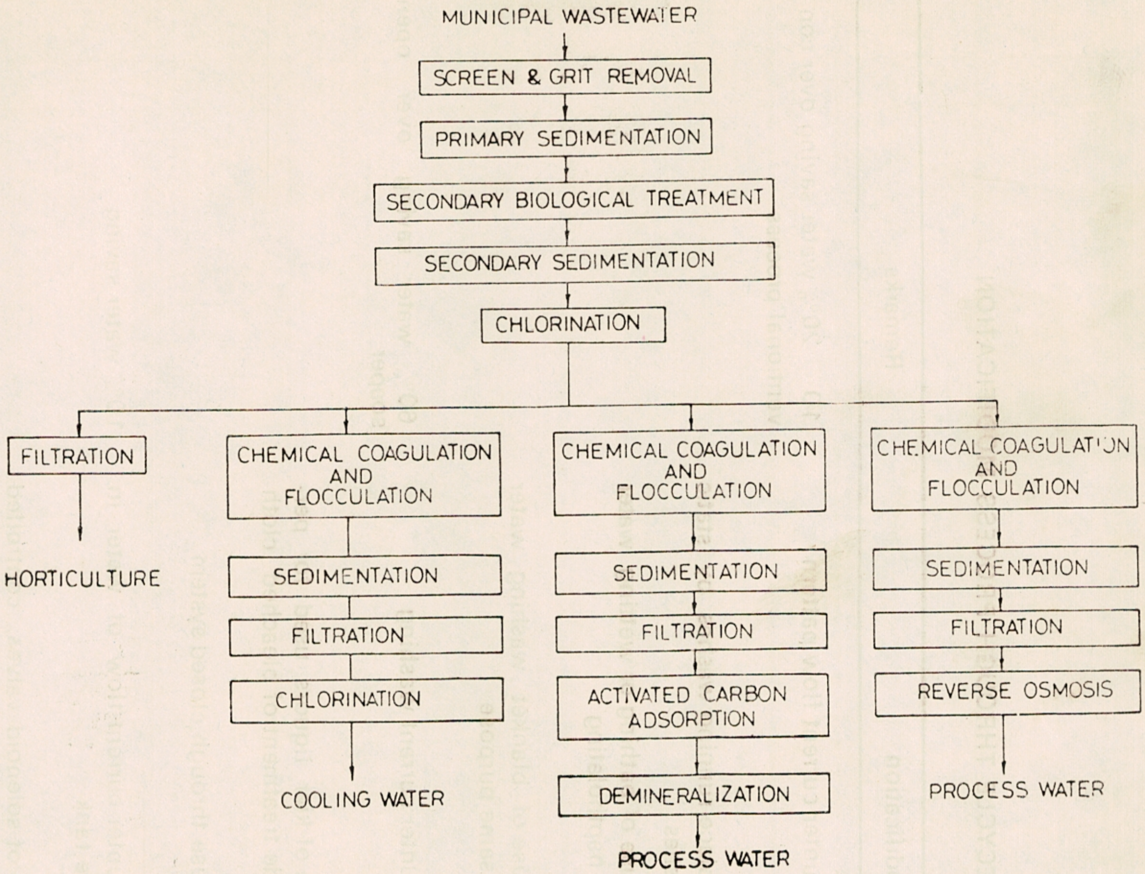

Fig. 3 — Treatment Scheme for Municipal Wastewater For Reuse

TABLE 5 : COST OF WATER PRODUCTION FROM BIOLOGICALLY TREATED SEWAGE

Sr. No.	Designated Use	Cost, Rs./m^3 (Flow = 1.8 mld)[6]	Flow = 1800 mld)[5]
1.	Horticulture	2.75	1.35
2.	Cooling water	3.75	1.87
3.	Process water	5.00	5.00

TABLE 6 : AVENUES FOR WATER RECYCLE THROUGH PROCESS MODIFICATION

Sr.	Name of Industry	Process	Modification	Remarks
1.	Textile	Mercerizing	Counter current flow pattern	10 = 20% water saving over conventional process
		Dyeing	Replace running washes by static washes	
			Reuse of bathing or wetting water for naptholating	
		Printing	Reuse of blanket washing water for same purpose	
		Washing of printed cloth	Counter current washing	60% water saving over open soaper
		Desizing	Use of kier liquors used for peroxide treatment of bleached cloth	
		Cooling water	Reuse through closed system	
2.	Metal Plating	Rinsing	Counter current flow of water in rinse tank	10% water saving
			Use of solenoid valves, controlled by conductivity bridges determining dissolved solids concentration in rinse tanks, instead of open tap system	

3.	Pulp & Paper	Pulp washing	Use of decanted water for pressure washing of unbleached pulp	
		Bleaching	Use of filtrate backwater for preparing bleaching water Use of alkali extraction stage filtrate as makeup water	
		Washing of bleached pulp	Use of back water from acid treated pulp for washing bleached pulp Use of hypochlorite bleaching stage excess filtrate in washing chlorinated pulp	
		Screening	Use of pulp dryer white water	20% water saving
		Dilution of bleached stock at hypostage	Use of pulp dryer white	10% water saving
4.	Steel rolling mills	Cooling	Recycle in closed system	66% water saving
5.	Distillery	Cooling	Recycle in close system	84% water saving
6.	Soap & detergent	Cooling	Recycle in close system	66% water saving
7.	Thermal power	Cooling	Recycle in close system	75% water saving

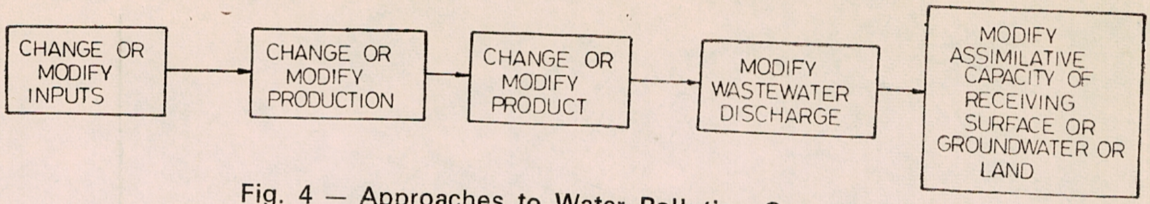

Fig. 4 — Approaches to Water Pollution Control

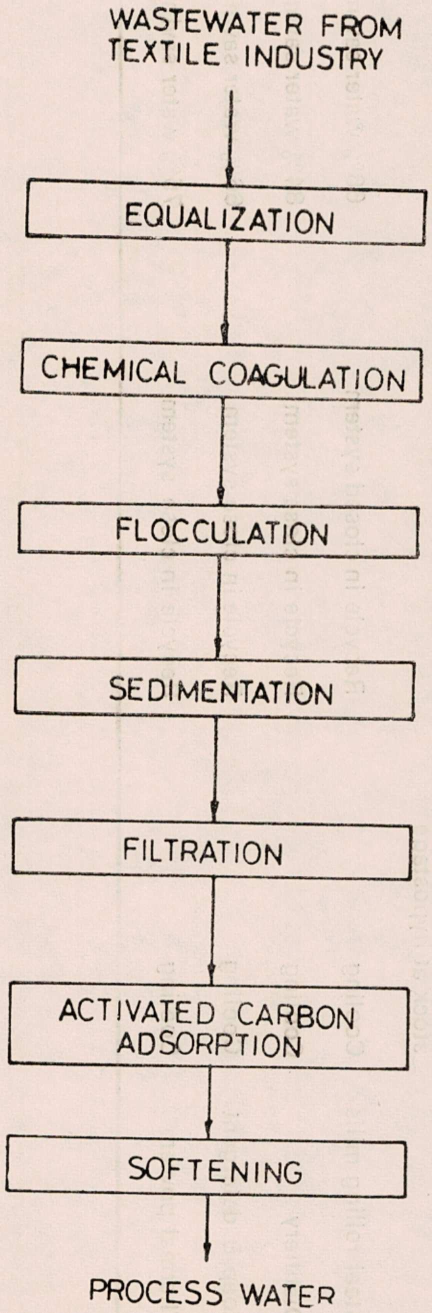

Fig. 5 — Treatment Cum Recycle Scheme for Textile Wastewater

and chlorination. The treated effluent could be reused as process water directly after softening or in admixture with freshwater. The dye affinity tests carried out on colour matching computer with treated and municipal water using three different types of dyes reveal K/S values (ratio of absorption coefficient to scattering coefficient) of 9.2889 and 9.4430 for fresh and recycle water. Thus, the recycle qater results in slightly better adsorption properly compared to fresh water. Hence, the most demanding parameter in textile industry, viz, dye affinity is in favour of recycle system. The cost-benefit analyses of wastewater recycle systems, detailed in Table 7 (8), indicate that the investment payback period of recycle system varies between 9 to 30 months depending on the tarrif for fresh water as also the type and quantity of processed textile.

The wastewater from food processing industries and vegetable oil refineries could be recycled after biological treatment followed by physico chemical treatment. The cost benefit analysis for these industries are presented in Tables 8 and 9 respectively (9).

4. Conclusion

The R & D endeavour presented in this paper is significant in the face of shrinking water resources and polluter acceptibility as it provides credence to the fact that the waste is misplaced resource and its pragmatic management could accrue economic incentives whilst fulfilling polluters social, legal and ecological obligations.

TABLE 7 : COST-BENEFIT ANALYSES OF TEXTILE RECYCLE SYSTEMS

Sr. No.	Industry	Waste water flow (m^3/d)	Cost of plant (Rs*10^5)	Net Recovery (Rs* 10^5/Yr)	Investment payback period (months)	Remarks
1.	M/s. Orkay Silk Mills, Bombay	300	3.5	3.75	11	Recycle in process house
2.	M/s. Premier Processors, Bombay	600	5.0	6.0	10	Recycle for ancillary use
3.	M/s. Mahajan Processors, Bombay	250	4.0	3.6	14	Recycle in procees house
4.	M/s. Bhilwara Processors, Bhilwara	900	7.5	10.0	9	Recycle in process house
5.	M/s. J.K. Cotton Spinning and Weaving Mills Co. Ltd., Kanpur	450	4.5	1.8	30	Recycle in process house
6.	M/s Elgin Mills Company Ltd., Kanpur Unit I	1700	9.0	9.0	12	Recycle in process house
7.	Synthetic and Industrial Corporation, Kanpur	200	2.5	1.2	24	Recycle in process house

Bombay water tarrif at the rate of Rs. 8/m^3
Kanpur and Bhilwara water tarrif at the rate of Rs. 4/m^3
1 US \$ = 12.5 Rs.

TABLE 8 : WASTEWATER MANAGEMENT - BEWERAGE INDUSTRY*

Sr. No.	Industry	Wastewater flow (m^3/d)	Capital cost ($Rs^* 10^5$)	Annual O & M (Rs^*10^5)	Remarks
1.	M/s. Arlem Breweries Ltd., Goa	400	4.0	0.75	Recycle for horticulture and cricket turf
2.	M/s. Mc Dowell Breweris Ltd., Goa	100	2.0	0.30	Recycle for horticulture
3.	M/s. Goa Bottling Co. Pvt. Ltd., Goa	50	0.9	0.20	Recycle for horticulture
4.	M/s. Vijayawada Bottling Co. Ltd., Krishna District	550	5.0	1.95	Recycle for horticulture

* Benefits from the wastewater management system in this category have not been quantified as the industry desired primary satisfaction of legal stipulations of pollution control boards

TABLE 9 : COST BENEFIT ANALYSIS - OIL PROCESSING INDUSTRY

Sr. No.	Industry	Wastewater flow (m^3/d)	Capital cost (Rs^*10^5)	Annual O & M (Rs^*10^5)	Annual cash (Rs^*10^5)	Investment payback (years)	Remarks
* 1.	The Ganesh Flour Mills Co. Ltd. Kanpur	800	3.0	1.12	3.0	1.59	Recycle for secondary uses and horticulture
2.	M.P. Udyog Ltd., Kanpur	75	1.5	0.45	—	—	To meet stipulations of UPPCB

* Industry operation for 300 days/year

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