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STRENGTH AND VOLUME REDUCTION OF WASTEWATER IN SUGAR INDUSTRY: A CASE STUDY OF VITTHALRAO SHINDE SAHAKARI SAKHAR KARKHANA LTD., PIMPELNER

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ABSTRACT:

Water plays a most valuable and important role in the natural cycles of various ecosystems Out of available water on earth, only 3% is fresh water available. In the available fresh water sources, entries of pollutants have been significantly increased from industries and domestic/anthropogenic activities. In case of sugar industry, wastewater is generated at various levels of unit operations and conservation of water and minimisation of wastewater is significant aspect of environmental and economical sustainability of sugar industry. This paper has proved that by adopting the technique of 4-R i.e. Reduce, Reuse, Recycle and Recovery concept at Vitthalrao Shinde Sahakari Sakhar Karkhana Ltd. (VSSSKL), Pimpelner, Dist: Solapur, Maharashtra the wastewater strength and volume reduction is possible.

KEYWORDS: Wastewater, 4-R, Sugar industry, strength, volume.

1. INTRODUCTION:

Since its independence, India has developed as the agro based country. Sugar industry is one of the most popular and second largest agro based industry. In India sugar industries plays the catalyst role in development of economic status of the country. Sugar industries require a huge quantity of water for the manufacturing process and generate a large amount of wastewater, which needs to be focused for minimization. The raw water requirement for sugar industry is 200- 400 lit/tonne and wastewater produced is about 200-300 lit/tonne of sugarcane crushed, (Deshmukh G. K. and Sonaje N. P., 2017). The pollution prevention practices and waste treatment methods require particular circumstance for success. Treatment processes are to be altered to suit the Indian versatile climatic conditions. In traditional pattern, sugar industry uses raw water in real practice, which can be avoided by different methods. Sugarcane itself contains about 70% of water; this water can be used for manufacturing of sugar, (Sonaje N. P. and Kulkarni A. A., 2015). Reduce, recycle, reuse and recovery (4-R) techniques at different units of the industry can minimize the water requirement and wastewater generation. The environmental problems are affecting the future prospects for sugar industry development in the country. The pollution prevention practices and waste treatment methods require particular circumstance for success.

Most of the industries are approaching towards the wastewater management, pollution prevention and waste minimisation, (Anon, 2000). The conventional approach to waste management provides required treatment of waste generated from different process operations which do not lead for better treatments in the long run. Traditional waste treatment in many instances leads to mere transformation of pollutants from one phase to another, while it requires substantial investment and budget to meet the operating cost, (Gunjal, *et.al.,* 2013).

The new approach to waste management aims to optimize the production process and minimize generation of waste and managing unavoidable waste in an environmentally acceptable and economical manner. The effective way to reduce pollution is to avoid the production of waste and to achieve the same, industries can modify the production processes, (MG Cortes, *et al.,* 2010). Recycling and reclaiming of wastewater that otherwise might be discarded in the waste stream, which also reduces the environmental pollution for economic as well as environmental benefits, (Agarwal, 2005 and Hulett, 1970).

Maharashtra a leading state in India for production of sugar, where few Industries have kept the pace with change in time and have not only conceptualized the necessary changes but have implemented them through their innovative ideas and stand out as the success stories in sugar industries sector. Vitthalrao Shinde Sahakari Sakhar Karkhana Ltd. (VSSSKL), Pimpelner, Dist: Solapur, is one of the leading industry in western Maharashtra established in 2001 with crushing capacity 2500 TCD. Since, its inception the industry has adopted various policies in the fields of cane development, technical efficiency and water

management etc with increasing crushing capacity from 2500 TCD to 8500 TCD and power plant capacity of 38 MW.

This paper attempt to analyse the technique of 4-R concept i.e. Reduce, Reuse, Recycle and Recovery concept adopted for wastewater minimisation at Vitthalrao Shinde Sahakari Sakhar Karkhana Ltd. (VSSSKL), Pimpelner, Dist: Solapur, Maharashtra.

SOURCES OF WASTEWATER GENERATION:

The wastewater generation depends upon efficient use of water, operation and maintenance of the industry. Attempts are always made for conservation of waste than providing the treatment after this generation. Water used in sugar industry is of two types, viz., cold water and condensed hot water. Conventionally, the cold water is used as make up water, injection water to the condenser, cooling water for various accessories such as mill bearing, turbine bearing, crystallizers, cold maceration, juice dilution, lime preparation, laboratory testing and factory equipment cleaning. The condensed hot water is used as boiler feed-water, juice dilution, lime and sulphate preparation, oliver filter washing, molasses conditioning, centrifugal, magma making, massecuite dilution, etc.

Hence the sources and causes of wastewater generation are studied for evaluation. Wastewater with varying levels of pollution load is generated at nearly all stages of sugar production. The quantity and quality of wastewater generation is different at all this stages. Characteristics of wastewater generated from various sections of the sugar industry vary widely. Different stages of the sugar industry produce the wastewater with varying quantity of pollutants. Various stages of unit operation where water is used and wastewater generated is shown in the Fig.1 and the sources of wastewater generated are as shown in Fig.2.

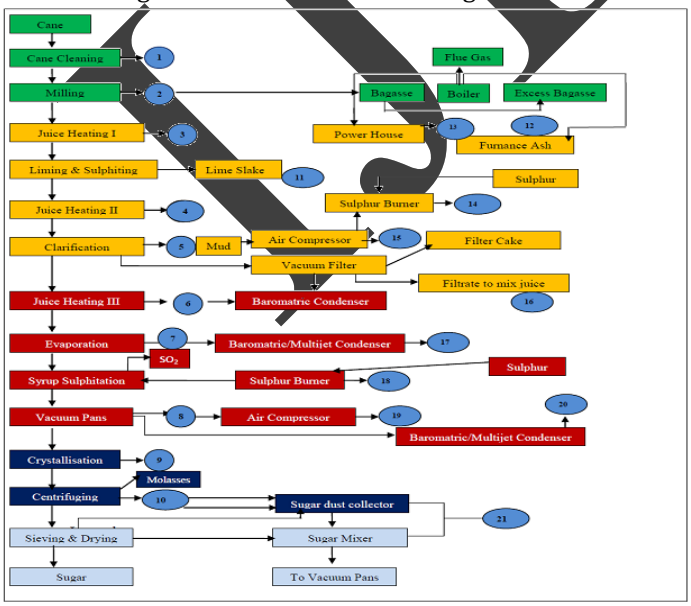

Fig.1: Stages of wastewater generation in a Typical Sugar Industry.

LEGEND:

1. Cane washing,
2. Bearing cooling, turbine cooling, floor washing, oily cum juicy wastewater
3. Juice Heater - Condensate (collected in condensate collection tank) floor washing and equipment washing,
4. Juice Heater - Condensate floor washing and equipment washing,
5. Clarification - Floor washing,
6. Clarification - Condensate floor washing and equipment washing,
7. Evaporator - Condensate floor washing and equipment washing,
8. Vacuum Pan - Condensate floor washing and equipment washing,
9. Crystallization - Condensate floor washing and equipment washing,
10. Centrifuging - Floor and equipment washing,
11. Liming and Sulphitation - Floor washing,
12. Boiler blow down,
13. Turbine cooling water,
14. Sulphur burner cooling water,
15. Sulphur air compressor, cooling water,
16. Vacuum filter condenser water,
17. Evaporator condenser water,
18. Sulphur burner cooling water,
19. Air Compressor cooling water,
20. Vacuum pan condensate,
21. Drying and Packing unit - Floor washing.

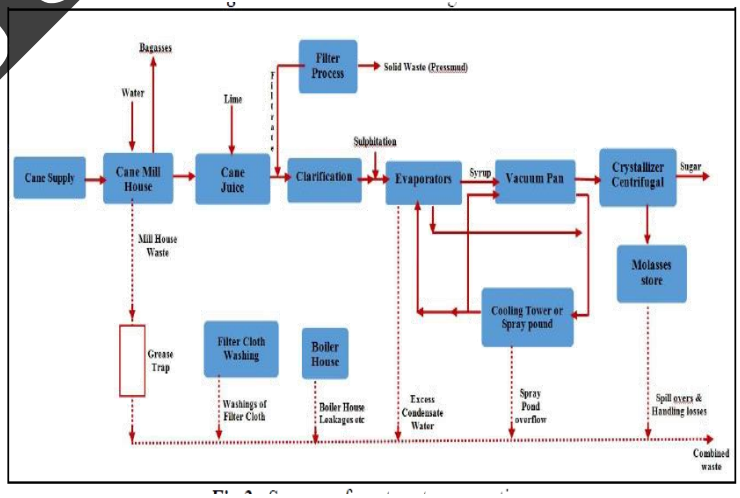

Fig.2: Sources of wastewater generation.

CAUSES OF POLLUTION:

The major causes of pollution are leakage, spill-over, overloading, indifferent handling and crushing operations, improper molasses storage and handling and so on. The typical causes of wastewater generation from different sources are as shown in Table 1, below,

Table 1: Typical causes of wastewater strength & volume generation from different sources

S N	Sources	Causes
1	Mill House (2)	Lubrication, Intermittent washings, Gland cooling
		Sugar juice from spills, leaks and overflows
2	Boiler Section	Boiler blow down (12)
3	Clarification Section (5)(6) Sulphur and Lime Houses (11) (14)	Periodical washings (3),(4) Washing and Cooling
4	Evaporator and pan boiling(7),(8)	Leakages and overflows from tank, floor & equipment washing.
		Entrainments through vapours from pan boiling and evaporator due to poor operating or overloading
5	Crystallization and Centrifugal House (9) (10)	Occasional spills and leaks due to poor housekeeping and maintenance
		Overflows

The sources, activity causing pollution, resulting form of waste and pollution parameters of concern pertaining to VSSSKL are given in Table 2 below,

Table 2: Wastewater Causes and Parameters at Different Sources (VSSSKL)

SN	Source	Activities causing pollution	Resulting form of waste	Parameters of concern
1	Mill house	Continuous gland cooling, intermittent floor washing, spill over, leakages, grease and oil from bearing lubrication	Oil and Grease, sugar juice spillage	Suspended solids, oil and grease, BOD.
2	Boiler section	Boiler blow down	Inorganic salt, ash.	TDS,
3	Clarification section Sulphur and lime house	Periodical ashings. Washing and Cooling	Inorganic and organic atter. Inorganic contents.	SS, TDS, BOD, COD. TDS.
4	Evaporator and pan boiling	High level of juice, Pump leakage, entrainments, mill overloading and poor operating condition.	Sugar loss into condensate.	SS,TDS,BOD,COD,
5	Crystallizer & centrifugal house, pumps, pipes, floor washings, molasses spillover, etc.	Occasional spills, overflows.	Waste discharged into drains.	SS, TDS, BOD, COD.
	Washing of vessels	Washings from scale removal and cleaning	High inorganic and low organic content.	TDS, BOD, COD
6	Molasses storage tanks (pan house)	Poor storage handling, leakage.	High pollution load spillage and leakage of Molasses	Very high BOD and COD

QUALITY AND QUANTITY OF WASTEWATER FROM SUGAR INDUSTRY:

The strength and volume of wastewater generated in sugar industry from different operations is collected separately in various sub streams is as discussed below:

- **MILL HOUSE:**

The wastewater consists of water use for cleaning of mill house floor is liable to mix with spilled and splashed (cleaning operation) sugar juice. Water used for cooling of mills bearings also form the part of wastewater of this stream. This wastewater contains organic matter like sucrose contributing BOD, Bagasse-cillo, oil and grease from the bearing fitted within the mills. The observed characteristics at VSSSKL are as follows,

Table 4: Mill house wastewater characteristics at VSSSKL

Characteristics	BOD (mg/L)	Oil and Grease (mg/L)	COD (mg/L)
VSSSKL	1200	150	2240

- **BOILING HOUSE:**

Wastewater from boiling house results from leakages, through pumps, pipeline and washings of clarification, evaporators, juice heaters, crystallization and centrifugation, etc. The cooling water from various pumps used in this section also forms a part of the wastewater of this stream.

Table 5: Boiling house wastewater characteristics of VSSSKL

BOD (mg/L**)**	**COD (**mg/L**)**
1840	3320

- **BOILER BLOW-DOWN:**

Water used in the boiler after repetitive uses get contaminated with high suspended and dissolved solids. These salts get concentrated after generation of steam from the original water volume. These solids have to be expelled from time to time to save the boilers from scaling.

Table 6: Boiler blow-down wastewater characteristics of VSSSKL

BOD	COD	SS	TDS
70 mg/L	120 mg/L	90 mg/L	490 mg/L

- **EXCESS CONDENSATE:**

The excess condensate normally does not content any pollutant and is used as a boiler feed water and for washing operations. Sometimes, it gets contaminated with juice due to entrainment of carryover of solids with vapours being condensate; in such cases it goes to the wastewater drain.

- **CONDENSER COOLING WATER:**

Condenser cooling water is recirculated till it get contaminated with juice, which is possible due to defective entrainment separators, faulty operation beyond the design rate of evaporation. If it gets contaminated the wastewater invariably go to the drain. The volume of this water gets increased with addition of condensing of vapours from the boiling juice in the pan.

Table 7: Condenser cooling wastewater characteristics of VSSSKL

BOD	COD	pH
140 mg/L	200 mg/L	7.2

➢ **WASHING OF SODA ACID WASTE:**

The heat exchangers and evaporators are cleaned with caustic soda and hydraulic acid in order to remove the deposits of scales on the surface tubing. The rinsing of soda and wash contributes to considerable amount of organic and inorganic pollutants and may cause shock loads to wastewater treatment plants. This operation is carried out once in a fortnight and the wastewater generated is stored in separate tank.

The combined wastewater characteristics from different sources in VSSSKL are compared with the typical characteristics, (Rao M.N, & Datta A.K) as per Table 8 below.

Table 8: Combined wastewater characteristics of VSSSKL

S N	Parameter	Unit	Typical	VSSSKL
1	pH	--	4.6-7.1	5.3
2	Total Solids	mg/L	870-3500	2800
3	Suspended Solids	mg/L	220-800	320
4	COD	mg/L	600-4380	3200
5	BOD	mg/L	300-2000	1750
6	Oil and Grease	mg/L	60-100	50
7	Flow	m^3/day	--	305

APPLICATION OF 4-R CONCEPT IN VSSSKL:

The strength and volume of wastewater can be reduced in sugar industry by adopting appropriate measures at various stages of production process with 4-R concept, Reduce-Reuse-Recycle-Recover adopted for strength and volume reduction of wastewater in VSSSKL is as mentioned in Table 3.

Table 3: 4-R concept adopted for strength and volume reduction of wastewater in VSSSKL

SN	Unit	Source of pollution / nature	Measures adopted	Concept
1	Milling section	Oil and grease	• Use of grease instead of oil • Use of collection trays.	• Reduce • Reduce
		Floor washings	• Proper slope to floors	• Reduce
		Leakages and spillovers	• Use of mechanical seals for all pump gland cooling • Overflow alarms	• Reduce • Reduce
		Mill bearing cooling water	Avoided external cooling. • Recycle bearing cooling water	Recycle • Recycle
2	Boiler house	Boiler blow-down	• Feed water quality control	• Reduce
3	Clarification and vacuum filters	Leakages from pumps, glands and pipe overflow	• Use of mechanical seals • Use of overflow alarms • Use of treated effluent for sulphur burner/ cooling water • For oliver filtrate pumping	• Reduce • Reduce • Recovery • Reduce

CONCLUSION:

The wastewater volume and strength can be reduced by adopting 4-R measures at various unit operations. At milling section the measure such as avoiding external cooling, recycling of cooling water, use of collection tray for excessive lubricants are implemented. In clarification section mechanical seals for pumps to avoid gland cooling water and alarms system to avoid overflow is implemented. In boiler, feed water quality control measures are observed. At evaporator and juice heating section, mechanical seals, use of poly baffle stainless steel, and additional external catchers are used to avoid entrainment sugar vapours to achieve reuse and recycle of condensate water. During cleaning operations, the frequency of cleaning is increased; also reuse of NaOH mixture solution for cleaning of vessels has resulted in reduction in strength and volume of wastewater.

It is observed from the current study of the 4-R concept adopted by VSSSKL shows the reduction in the strength and volume of wastewater generated.

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REFERENCES:

1) Agarwal P. K. (2005), "*Water Management & Waste water recycling in Sugar Industry for Zero Pollution"*, Proceeding of 8th Joint Conv. of Three Associations, pp. 32 – 62.
2) Anon (2000), "*Water Management in Sugar Factory*", Manual of Training Program on Waste Water Management in Sugar factory, Conducted by VSI, Pune, pp. 30 – 49.
3) Ashwani Kumar (2003) *Handbook of waste Management sugar Mills and Distilleries.*
4) Baban Gunjal and Aparna Gunjal (2013), "*Water Conservation in Sugar Industry*", Journal of Nature Environment and Pollution Technology, Vol. 12 No. 2, pp. 325 – 330.
5) Deshmukh G K and Sonaje N P (2017): "*Water Conservation in Sugar Industry: A Case Study of Lokmangal Sugar, Ethanol and Co-generation Industries Ltd., Bhandarkavathe*", paper published in International Journal of Innovations in Engineering

Research and Technology (IJIERT), Vol. 4, Issue 8, pp. 20 – 26.

6) E. Hugot, *"Handbook of Cane Sugar Engineering"*
7) Gunjal (2013), "*Water Conservation in Sugar Industry"*, Nature Environment and Pollution Technology, Vol. 12, pp. 325 – 330.
8) Hulett D. J. L. (1970), *"Water Conservation in Sugar Mills*", Proc. Of the South African Sugar Tech. Association, pp. 57 – 59.
9) Kumana (1996) "*Water Conservation and Wastewater Minimisation through Process Integration",* Paper 57m at 5thWorld Chem Eng Congress, San Diego.
10) M. Karthikeyan& J. Prem Kumar (2005), "*Near Zero"* – Raw Water Consumption for Processing and other raw water conservation, measures adopted at Rajeshree Sugars and Chemicals Ltd., Mundiampakkam Unit, Journal of Environmental Engineering, Vol. 2, pp. 41 – 49.
11) MG Cortés, H Verelst, RE Pedraja, E González (2010), "*Water and Wastewater Management in a Sugar Process Production",* Proceedings on Sugar Industry Technology.
12) Palazzo A. (2004), "*Mill-Wide Water Management in the South African Sugar Industry*", Proc. South African Sugar Technology Association, Vol. 78, pg. 419-426.
13) Rao M.N and Datta A.K. (1987) *Waste water Treatment Rational Methods of Design and Industrial Practices*
14) Sapkal, D. B., Bhoumik J. N and Dani R. V. (2012), "*Water Conservation and Wastewater reduction in Sugar Processing",* at National Seminar on Recent Trends in Water Management in Sugar processing organized by VSI, Pune.
15) Sapkal, D. B., Deshmukh B. M., Burse V. R., Gund T. D. and Dani R. V. (2013), "*Water Conservation A Case Study of Dr. Babasaheb Amedkar S. S. K. Ltd., Osmanabad",* Proc. of 72nd Annual Convention of STAI, pp. 358-370.
16) Sapkal, D. B., Divekar, U. D. and Gunjal, B. B. (1997), "*Water Management in Sugar Industry – A Case Study",* 59th STAI Annual Convention, pg. 43-58.
17) Shiva Kumar, D. and Srikantaswamy, S., (2015), "*Evaluation of Effluent Quality of Sugar Industry by Using Physico- Chemical Parameters,*" International Journal of Advanced Research in Engineering and Applied Sciences, pg. 16-25.
18) V. Sriram and P K. Dash (2013), "*Conservation of water by adopting effective cooling water treatment programmes for efficient running of cooling towers",* at All India Seminar on Water and Wastewater Management in Sugar Industries, pp. 27-35.