RESEARCH PAPER:

Assessment of pollution load of winery wastewater collected during vintage and non-vintage seasons and analysis of wastewater irrigated soil

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SUMMARY

The waste water from the wine producing industry has been collected in two distinct seasonally representative situations: the vintage and non-vintage seasons of the year. However, concentration values were higher than limits allowed by local authority for discharge into the municipal sewage system. The wastewater is strong and highly variable in terms of pollutants, and tends to become odorous upon standing. Chemical oxygen demand (COD), Biological oxygen demand (BOD) and Total dissolved solid (TDS) were the major pollutant present in the winery waste water. When soil conditions are suitable, land treatment of wastewater for irrigated cropping or forestry systems can be successfully practiced, especially with low pollution wastewater. However, on poorly drained soils, effluent irrigation can lead to water logging as well as salinization and sodification due to inadequate salt leaching.

Key words : Winery waste water, Vintage and non vintage season, Wastewater irrigated soil

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The wine industry in India is projected to grow at more than 25 per cent annually in the next decade, making it the fastest growing industry in the country. The investment in wine industry in Maharashtra has increased by 32.80 % in the financial year 2007-08, against Rs. 247.71 crores in the previous year, with the establishment of new wineries. Around seven new wineries, including one in Buldhana, two each in Nasik, Pune and Sangli were set up this year. More than Rs. 81.26 crores was invested in these seven wineries. Today, the state has 58 wineries and total investment in these wineries is around Rs. 328.97 crores (Pawar, 2008).

The worldwide wine production is 261 x 10^5 m^3 of which 69% from Europe, 18% from America, 5% from Asia, 4% from Africa and 4% from Oceanea. The worldwide wine consumption is 228x10^5 m^3, distributed by Europe (68%), America (20%), Asia (7%), Africa (3%) and Oceanea (2%) (Nakov *et al.*, 2002).

All the quality and quantity of winery waste differs significantly from season to season. Winery waste can be divided into vintage season and non-vintage season waste. The vintage season begins in August and lasts until February and the non-vintage season involves the period from early March till the end of July. Each period generates different types of waste and different qualities and thus, waste should be treated separately for each season applying the necessary modification in every case. During every vintage period, bigger amount of winery waste water is released than the non-vintage period.

The present work deals with a laboratory scale attempt to know the pollution load generated by wastewater from medium scale wine industry, before discharging it into a municipal sewage treatment plant. The aim is to assess an efficient and economic system capable of reducing the concentration of pollutant below the limits imposed by BIS regulations (COD=250 mg/l, BOD=30 mg/l, TSS=100 mg/l). Winery wastewater contains high concentration of nutrients, such as high concentration of organic compounds nitrates and phosphates.(Busamante *et al.*, 2005) As a result waste water discharge, irrigation and reuse cannot be undertaken without prior treatment. Both of which lead to reduction in biological oxygen demand (BOD) and chemical oxygen demand (COD). The activity of winery water has resulted in investigation of several treatment methods. Wastewater from the wine industry has a high organic content, contains both suspended solid (TSS) and total dissolved solid TDS and is acidic. Increased concentration of (TDS) can close soil pores and limits the aeration of soil and the flow of water through soil. Concentrated organic

industrial waste such as winery effluents and wastes resulting from the manufacture of various wineries generally create serious treatments or disposal problem for the industry or local authority concern because of their high organic load. In the vineyard, the philosophy was to take the least polluting path. Minimal chemical use, or choice of environmentally-friendly products, and the use of cover crops aid maintenance of soil health. Irrigation is minimized because rainfall levels are adequate, the soil has good moisture holding capacity and the undulating topography is unsuitable to receive high levels of irrigation. Perhaps the most significant reason that irrigation is minimized is that the producers are not under pressure to produce high yields where this compromises quality (Chapman,1996).

Study area:

The Nasik district is the study area. The state's grape wine industry got a big boost due to the Maharashtra grape processing industrial policy in 2001. The number of winery in Nasik district are 30 and Nasik today has emerged as the wine capital of India. A climate conducive, both to grape growing and wine making, along with favourable 'Grape Processing Industry Policy' of the Maharashtra government, has made Nasik the hub of this industry.

MATERIALS AND METHODS

The effluent was collected from winery industries established in the Nasik district of Maharashtra state where much of the waste water is discharged outside of the winery industry during vintage and non-vintage seasons. The waste water irrigated soil samples were also taken for analysis. So, the samples taken were winery wastewater effluent, wastewater from pond and waste water irrigated soil, during the vintage season and non-vintage seasons. The physicochemical properties of the winery waste water, waste water from pond and waste water irrigated soil were analyzed by the procedure of APHA and the standard methods were followed for the data recording.(APHA/AWA,1992).

Wastewater sampling:

Winery wastewater composition is highly variable. The samples were taken during vintage and non-vintage seasons. Samples were collected in polythene canes and returned to the laboratory for analysis. The first water samples were taken from outlet sump and second from the aerobic pond.

Soil sampling:

Soil samples were collected from the wastewater irrigated farms in order to assess the changes in the soil after irrigation with wastewater application. Three separate soil cores were collected at random sites in the wastewater irrigated farm to a depth of 60 cm and divided into three sections: 0-20 cm, 20-40 cm, 40-60 cm. The samples from each depth were bulked together and physical and chemical analysis was undertaken. Soil sampling was also undertaken prior to each wastewater application to the wastewater irrigated farm. A 10 cm top soil sample was analyzed for pH, electrical conductivity (EC) and water content. (Wei Yuan-an and Xu Yuan-jin, 2004).

Physicochemical analysis:

Physico-chemical characteristics of the wastewater such as pH, EC, nitrate, phosphate, total organic carbon (TOC) and total suspended solids (TSS) were analyzed following standard wastewater analysis methods. Chemical oxygen demand (COD) was determined using a commercially available reflux condensation method.

RESULTS AND DISCUSSION

The temperature of winery wastewater effluent and wastewater from pond was 30.0°C and 27.0°C during vintage season and 32.0°C and 28.0°C during the non-vintage season. pH of winery wastewater and wastewater from pond were 3.0 and 6.0 during vintage season and 5.0 and 4.0 during non-vintage season. The pH influences solubility reactions in the irrigated soil. The range of pH according to BIS is 5.5-9.0. During vintage season the pH values of winery wastewater correspond to acidic nature of it (Table 1). The physico-chemical characteristics of minery wastewater have been dispacted by Fig. 1 and 2).

The average values of total suspended solid (TSS) 300 mg/lit. during both, vintage and non-vintage seasons for winery wastewater effluent and wastewater from pond which was very high as compared to the BIS recommended range *i.e.* 100 mg/ lit. During vintage season, total dissolved solid (TDS) from winery wastewater and for pond wastewater were 1915 mg/ lit. and 2000 mg/ lit, respectively which are in the limits of BIS, *i.e.* 2100 mg/ lit. The observed TDS values were 3100 mg/ lit. and 2655 mg/ lit. for winery and pond wastewaters during non-vintage season which are very large compared to the recommended limits of BIS. During vintage season total solids (TS) value for winery wastewater and pond wastewater were 2200 mg/ lit. and 2300 mg/ lit. which are slightly higher than the BIS limit. During non-vintage season, the TS values were 3400 mg/ lit. and 2970 mg/ lit. which are more than BIS limit *i.e.*2100

Table 1 : Physico-chemical analysis of winery wastewater effluent collected from outlet sump and aerobic pond during vintage and non vintage season

Sr. No.	Parameters	Vintage season		Non vintage season		BIS Standard
		WWW	PWW	WWW	PWW	
1.	Temperature	30.0	27.0	32.0	28.0	40.0
2.	pH	3.0	6.0	5.0	4.0	5.5-9.0
3.	Conductivity	0.58	1.00	0.57	1.04	-
4.	Total suspended solids	285	300	300	315	100
5.	Total dissolved solids	1915	2000	3100	2655	2100
6.	Total solids	2200	2300	3400	2970	2100
7.	BOD	350	400	200	350	30
8.	COD	600	800	400	460	250
9.	Nitrate	0.62	0.64	2.5	3.5	45
10.	Phosphate	0.45	0.47	1.00	1.20	45
11.	Sulphate	900	951	751	709	200

All values are in mg/ lit., except pH, Temp. in ^{o}C, and conductivity in µ mhos/cm, WWW-Winery Waste Water, PWW- Pond Waste Water .

mg/ lit. The higher amount of solids may be due to presence of crushed plant tissues and higher use of salts during the operation (Table 1).

The biological oxygen demand (BOD) for winery wastewater effluent and pond waste water were 350 mg/ lit. and 400 mg/ lit., respectively during vintage season and 200 mg/ lit. and 350 mg/ lit respectively for non-vintage season. The permissible level of BOD by BIS is 30 mg/ lit. for industrial wastewater. The observed values of BOD for winery effluent and pond wastewater were much higher and indicates high organic load. The higher values of BOD may be due to spilled wine and yeast etc. COD measures the amount of oxygen required for the oxidation of organic compound present in water by means of chemical reaction. Chemical oxygen demand (COD), for winery effluent and pond wastewater was 600 mg/ lit. and 800mg/ lit., respectively during vintage season and 400 mg/ lit. and 460mg/ lit. during non-vintage season. COD values are higher during vintage season and much higher in non-vintage season, as the range recommended by BIS is 250 mg/ lit. The higher values of COD may be due to processing chemicals like ferric oxide, aromatic compounds etc. (Table 1).

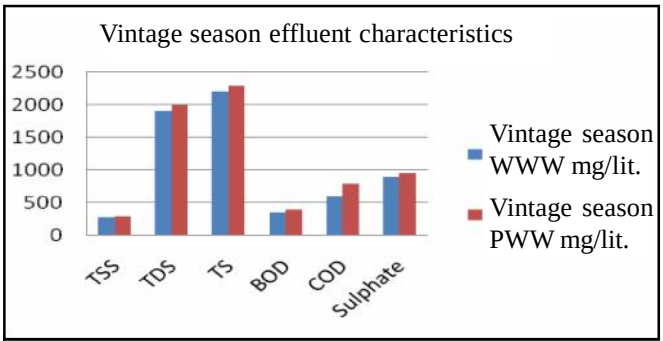

Fig. 1 : Physico-chemical characteristics of winery wastewater effluent sampled during vintage season

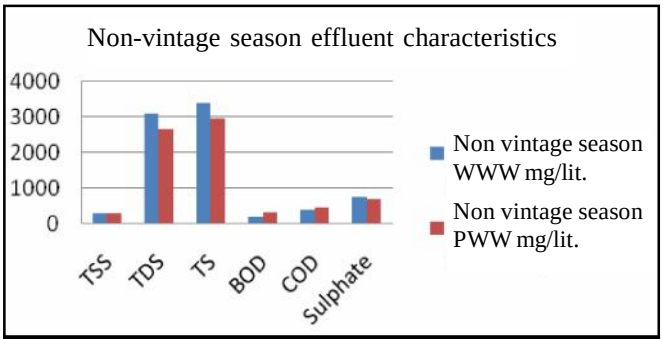

Fig. 2 : Physico-chemical characteristics of winery wastewater effluent sampled during non vintage season

Concentration of nitrate for winery effluent and pond waste water was in permissible limit of BIS, *i.e.* 0.62 mg/ lit. and 0.64 mg/ lit., respectively during vintage season. The same were 2.5 mg/ lit. and 3.5 mg/ lit. during the non-vintage period. The BIS limit for nitrate is 45 mg/ lit., and the observed nitrate concentration is bellow the permissible limit but more in vintage than non-vintage season. The range recommended by BIS for phosphate is also 45 mg/ lit. Concentration of phosphate during vintage season from winery effluent and pond wastewater was 0.45 mg/ lit. and 0.47 mg/ lit., respectively and during non-vintage season it was 1.00 mg/ lit. and 1.20 mg/ lit. The phosphate concentration is always below the permissible limit laid down by BIS. The sulphate concentration for winery effluent and pond wastewater was 900 mg/ lit. and 951 mg/ lit., respectively in vintage season and in non-vintage season the same was 751 mg/ lit. and 709 mg/ lit., but these values are very high as

compared to BIS limit which is 200 mg/ lit. (Table 1).

It is evident from Table 2 that the winery wastewater irrigated soil, pH was 4 during vintage season *i.e.* poor production potential and during non-vintage season it was 6, *i.e.* normal productions potential. This is favourable as availability of most plant nutrients depends on soil pH. The soil pH influences the solubility reactions. Electrical conductance (EC) is a measure of total soluble salts in the sample. EC values during vintage and non-vintage season were 0.65 and 0.59 µ mhos/ cm, *i.e.* with high production potential in both the seasons. The Central Pollution Control Board (CPCB) has fixed a permissible limit of 0.2-0.5 µ mhos/ cm for farm irrigated soil. Organic carbon % in the soil samples were 0.55 % during vintage and 0.78 % during the non-vintage seasons. The carbon % was with normal production potential as the CPCB range is 0.5-0.75 %. Nitrogen content of wastewater irrigated soil was 8.0 and 7.0 %, respectively, during vintage and non-vintage season. Phosphorous content was 6.0 and 5.0 % during vintage and non-vintage seasons. The soil was poor with respect to phosphate content and the CPCB recommended range for farm irrigated soil was <20 %. The potassium contents of soil were 9.0 and 4.0 % for vintage and non-vintage season, respectively, *i.e.* soil was with poor production potential with respect to nitrate as the standard fixed by CPCB is <110 % potassium. The sodium content of soil was 3.8 and 4.9 % during vintage and non-vintage season, respectively. As compared to the standard of CPCB which was <5 % sodium, the soil is with high production potential with respect to sodium during both the seasons (Table 2).

Table 2 : Physico-chemical analysis of winery wastewater irrigated soil during vintage and non vintage season

Sr. No.	Parameters	Vintage season	Non vintage season	CPCB standard
1.	pH	4.0	6.0	5.5-6.5
2.	Conductivity	0. 65	0.59	0.5-4.0
3.	Organic carbon	0.55	0.78	0.5-0.75
4.	Nitrogen	8.0	7.0	-
5.	Phosphorous	6.0	5.0	<20
6.	Potassium	9.0	4.0	<110
7.	Sodium	3.8	4.9	<5

All values are in %, except pH and conductivity in µ mhos/ cm.

Conclusion:

From the analysis results It is concluded that, the higher pollution load was observed in vintage season than non-vintage season for winery wastewater effluent, pond wastewater and for wastewater irrigated soil. It is beneficial to know the production potential of soil which may be normal, poor or high production potential during vintage and non-vintage seasons. The waste water discharged from winery industry during vintage season should be given various biological and chemical treatments to reduce the pollution load which are cost effective and suitable and for improve profit margin of the winery. The treated effluent can be used for farm irrigation. The effluent obtained during non-vintage period may be applied for crop irrigation without much treatment except ponding and lagooning.

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