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Physico-chemical Characterization of Distillery Effluent and its Dilution Effect at Different Levels

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ABSTRACT

Effluent originating from distilleries known as spent wash leads to extensive water pollution. A study was conducted to know the quality of effluent generated from the distillery, for the purpose of proper treatment and dilution of effluent before discharge in water stream or on land. Physico-chemical characteristics of distillery effluent samples such as colour, odour, Total Solids, Total dissolved solids, Total Suspended Solids, pH, Electrical Conductivity, Total hardness, Calcium, Magnesium, Alkalinity, Chloride, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Ammonical Nitrogen, Total Phosphorus, and Total Potassium were analysed and it was observed that the characteristics of spent wash and PTDE (primary treated distillery effluent) have high load of chemical and organic pollutants. But when PTDE was diluted with 50% and 75% of water, all the values of physicochemical properties were decreased. The decrease in these values show that the toxicity of distillery effluent decreases with increasing dilution. Thus the characteristics of spent wash and PTDE do not allow its discharge into a waterbody, hence it requires treatment and dilution before discharge.
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Key words: Distillery effluent, Physico-chemical properties, PTDE.

INTRODUCTION

Distillery spent wash is perceived as one of the serious pollution problems of the countries producing alcohol from the fermentation and subsequent distillation of sugar cane molasses. The distillery spent wash is characterised as one of the caramelized and recalcitrant wastes containing extremely high COD, BOD, inorganic solids, color and low in pH **(1, 2).**

In a developing country like India, distillery industries have become a major source of pollution, as 88% of its raw materials are converted into waste and discharged into the water bodies **(3)**, causing water pollution. The disposal of large quantities of biodegradable waste without adequate treatment results in significant environmental pollution. This is the major source of aquatic and soil pollution. The discharge of wastewaters from distilleries is becoming increasingly restricted as pressures from environmental regulations increase and as awareness of the negative impacts of seasonal discharges of water containing high nutrient and organic loadings into water courses spreads **(4)**. At present, there are 285 distilleries in India that are producing 2.7 billion liters of alcohol and generating 40 billion liters of wastewaters annually **(5).** Distilleries, the alcohol producing industries, are one of the major polluting industries. A typical cane molasses based distillery generates 15 L of spent wash per litre of ethanol produced **(6).**

The post methanation distillery effluent (PME) produced from the treatment is characterised by high biological oxygen demand (BOD) and chemical oxygen demand (COD), intense brown colour and high salt levels apart from being rich in plant nutrients. Though the biomethanation of distillery effluent under anaerobic conditions brings down its BOD load from around 50,000 mg /l to 8,000-5,000 mg/l, due to their high organic load and salts, further treatment is still needed. If these effluents are discharged to water streams, the suspended solids present in the effluent would impart turbidity in water, reduce light penetration and impair biological activity of aquatic life. Hence an economically viable and environmentally safe means of disposal is needed to handle such large volumes of PME **(7).**

Analysis on physicochemical characteristics of distillery waste has been carried out, **(8, 9, 10)** which stated that molasses is the most common raw material used in distilleries for bio-ethanol production. After alcohol distillation, huge volume of darkish coloured spent wash remains in the stills. The wastewater generally known as 'spent wash' is one of the most difficult waste products to dispose off, because of low pH and dark brown colour. It has high chemical oxygen demand (COD) and biological oxygen demand (BOD), causing pollution in the receiving water.

The Distillery effluent i.e. spent wash is of extremely polluting nature. There have been also numerous studies done on impact of distillery effluent on soil and water quality **(11, 12, 13, 14, 15).** Therefore, the main objectives of the present study are to evaluate the dilution effect of different application rates of distillery effluent.

MATERIALS AND METHODS

The sampling and analysis of various physico-chemical properties has been done to understand the composition of distillery effluent. The effluent samples were collected from Lord's distillery Ltd., Nandgaj, Ghazipur, U.P., India, samples were stored in dark place and the physico-chemical analysis of spent wash (distillery effluent), Primary treated distillery effluent (PTDE) and its dilution at different levels was studied i.e. its dilution with 50% and 75% of water were analysed for selected relevant physico-chemical parameters according to internationally accepted procedures and standard methods. **(16).**

RESULTS AND DISCUSSION

The physicochemical properties of spent wash, PTDE (Primary Treated Distillery Effluent), PTDE diluted with 50% water and PTDE diluted with 75% of water was studied. Chemical composition such as colour, odour, Total Solids (TS), Total dissolved solids (TDS), Total Suspended Solids (TSS), pH, Electrical Conductivity (EC), Total hardness, Calcium(Ca), Magnesium (Mg), Alkalinity, Chloride (Cl), Dissolved Oxygen (D.O), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammonical Nitrogen, Total Phosphorus, and Total Potassium were analysed and tabulated **(Table 1)**. The data revealed great variation at different dilution levels of effluent. The spent wash and PTDE (Primary Treated Distillery Effluent) shows the higher values at all physicochemical parameters. All the values decreased with increasing dilution whereas dissolved oxygen was increased.

Colour

The colour of spent wash was found dark brown. The colour of spent wash is suspected due to presence of a derivative of caramelized sugar formed during the distillation, termed melanoidin **(9)**. The colour of PTDE (Primary Treated Distillery Effluent) was reddish brown while when it was diluted with 50% of water it turned brownish in colour and changed to light brown colour in PTDE diluted with 75% of water.

Odour

Odour of the distillery effluent was offensive. Odourous compounds from distillery waste water mainly consist of volatile fatty acids such as butyric and valeric acids that have a high odour index**.** Distillery has distinct organic compositions. Various anaerobic bacteria ferment these compounds and generate products such as volatile fatty acids for example glycerol is fermented into butyric acid by clostridium butyricum **(17)**. The offensive odour of effluent was also reported **(8)**. Odour of the PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water was also offensive.

Total Solids

The total solids of spent wash were 42400.2 mg/l, but when it was treated, the value decreased. Total solids are the residues that include both dissolved solids and suspended solids. Distillery effluents contain huge amount of solids.

The total solids of the distillery effluent at different dilution levels decreased with dilution i.e. 28060.4 mg/l in PTDE, 16120.2 mg/l in PTDE diluted with 50% of water and 10432.8 mg/l in PTDE diluted with 75% of water.

Total Dissolved Solids
The total dissolved solids of spent wash were 38200.2 mg/l. The total dissolved solids of the distillery effluent at different dilution levels were 22616.4 mg/l in PTDE, 12354.0 mg/l in PTDE diluted with 50% of water and 8010.8 mg/l in PTDE diluted with 75% of water.

Total Suspended Solids
The total suspended solids of spent wash were 4200.0 mg/l. The TSS of the distillery effluent at different dilution levels were 5444.0 mg/l in PTDE, 3766.0 mg/l in PTDE diluted with 50% of water and 2422.0 mg/l in PTDE diluted with 75% of water.

pH
The pH of the spent wash was acidic in nature i.e. 4.2 (the raw spent wash is acidic in nature and the pH values of distillery wastewaters range from 3.5 to 5.0) (**18, 19, 20, 21)**. But when it was diluted with different dilution, it changed neutral to alkaline. The pH of distillery effluent at different dilution levels was 7.4, 7.6 and 7.7 at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively. It shows the pH increases with dilution.

Electrical Conductivity
The electrical conductivity of the spent wash was 16450.8 (µmho/cm). The EC of distillery effluent at different dilution level was 14800.8, 8380.0 and 3476.2 (µmho/cm) at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively. The electrical conductivity of distillery effluent was high but when it was diluted, value decreased with increased dilution **(22).**

Total Hardness
The total hardness of the spent wash was 2432.4 mg/l. The term total hardness indicates the concentration of calcium and magnesium ions. The total hardness of the effluent at different dilution level was 2060.8 mg/l, 1354.2 mg/l and 940.2 mg/l observed at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively. The hardness was also higher in spent wash and decreased with increasing dilution.

Calcium
The calcium of the spent wash was 2070.0 mg/l. The calcium content of distillery effluent at different dilution level was 872.0 mg/l, 610.2 mg/l and 422.4 mg/l observed at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Magnesium
The magnesium of the spent wash was 2260.5 mg/l. The magnesium content of distillery effluent at different dilution levels was 1742.0 mg/l, 992.0 mg/l and 684.6 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Alkalinity
The alkalinity of the spent wash was 2864.5 mg/l. The alkalinity of distillery effluent at different dilution levels was 3680.4 mg/l, 1880.0 mg/l and 1260.5 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Chloride
The chloride of the spent wash was 8530.2 mg/l. The chloride content of distillery effluent at different dilution levels was 5352.6 mg/l, 2362.4 mg/l and 1464.4 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Dissolve Oxygen
The D.O. was nil in spent wash and partially treated distillery effluent (PTDE) and the value was increased to 2.6 mg/l when PTDE was diluted with 50% of water, and 3.6 mg/l when PTDE diluted with 75% of water. The value of DO was increased with increasing dilution.

Table 1: Physicochemical characteristics of spent wash (Distillery effluent) and it dilution at different levels
Mean of triplicate samples (Mean ±Std. error of mean) ; (Values are in mg/ l unless otherwise stated).

PARAMETERS	SPENT WASH	PTDE (Primary Treated Distillery Effluent)	PTDE diluted with 50% water	PTDE diluted with 75% water
Colour	Dark brown	Reddish brown	Brown	Light brown
Odour	Unpleasant	Offensive	Offensive	Offensive
Total solids	42400.2 ± 6.4	28060.4 ±16.0	16120.2 ±8.0	10432.8 ±12.4
Total Dissolve solids	38200.2 ± 4.8	22616.4 ±32.0	12354.0 ±10.0	8010.8 ±14.6
Total suspended solids	4200.0 ± 0.0	5444.0 ±0.0	3766.0 ±0.0	2422.0 ±0.0
pH	4.2 ± 1.2	7.4 ±0.8	7.6 ±0.6	7.7 ±1.4
EC (µmho/cm)	16450.8 ± 8.2	14800.2 ±12.4	8380.6 ±14.8	3476.8 ±16.4
Total Hardness	2432.4 ± 5.4	2060.8 ±5.6	1354.2 ±6.3	940.2 ±8.2
Calcium	2070.0 ± 2.6	872.0 ±6.2	610.2 ±4.0	422.4 ±6.2
Magnesium	2260.5 ± 6.7	1742.0 ±8.0	992.0 ±8.3	684.6 ±8.8
Alkalinity	2864.5 ± 8.0	3680.4 ±12.0	1880.0 ±10.0	1260.5 ±12.1
Chloride	8530.2 ± 8.3	5352.6 ±12.2	2362.4 ±6.0	1464.4±14.0
Dissolve Oxygen	Nil	Nil	2.6 ±0.4	3.6 ±1.3
Biological Oxygen Demand	32300.8 ± 10.8	14824.2 ±12.0	6890.5 ±16.2	3240.8 ±12.0
Chemical oxygen Demand	57164.6 ± 12.9	32030.2 ±16.2	11448.6 ±16.2	4254.8 ±14.5
Ammonical Nitrogen	1254.4 ± 2.4	714.2 ±12.2	412.3 ±6.4	286.6 ±8.0
Total Phosphorus	44.4 ± 5.6	32. 8 ±3.5	22.4 ±2.3	12.8 ±1.3
Total Potassium	7440.2 ± 3.8	5360.8 ±14.4	2854.2 ±8.2	1482.0 ±10.6

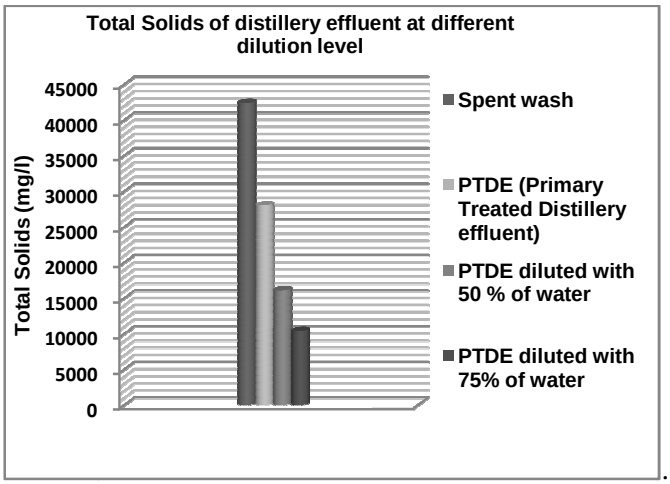

Fig. 1: Total Solids of distillery effluent at different dilution levels

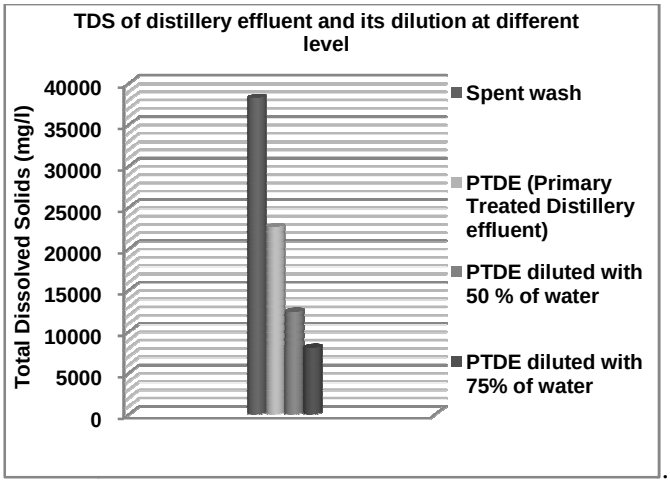

Fig. 2: Total Dissolved Solids of distillery effluent at different dilution levels

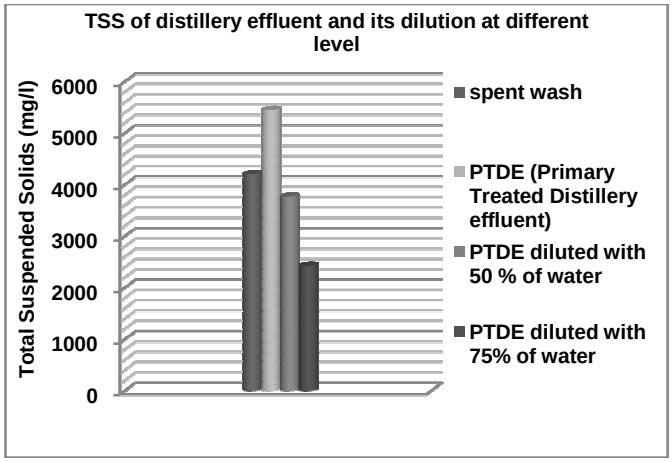

Fig. 3: Total Suspended Solids of distillery effluent at different dilution levels

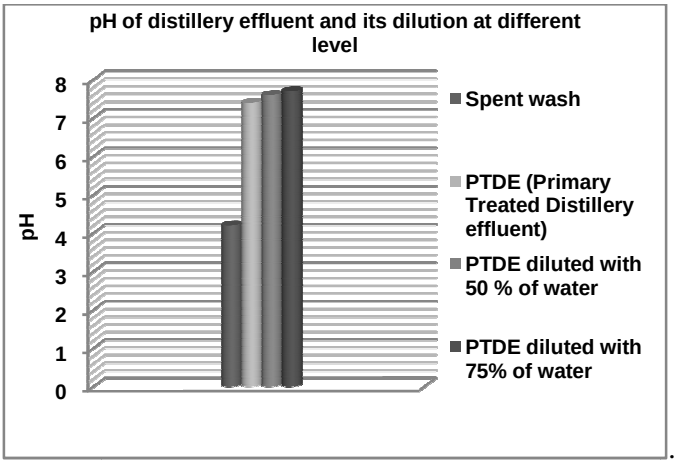

Fig.4: pH of distillery effluent at different dilution levels

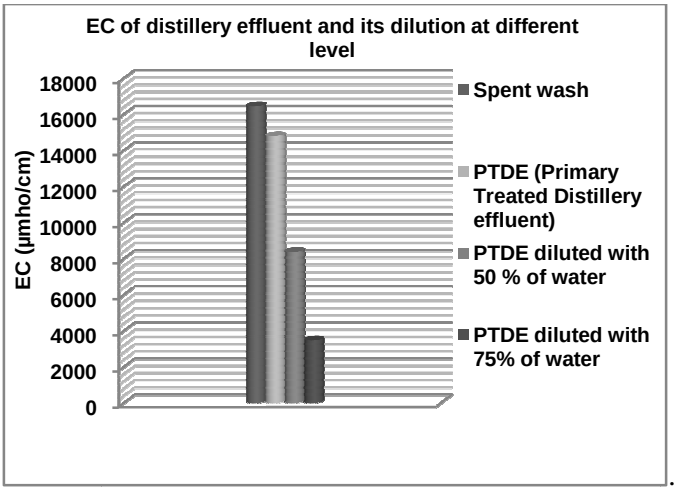

Fig. 5: Electrical conductivity of distillery effluent at different dilution levels

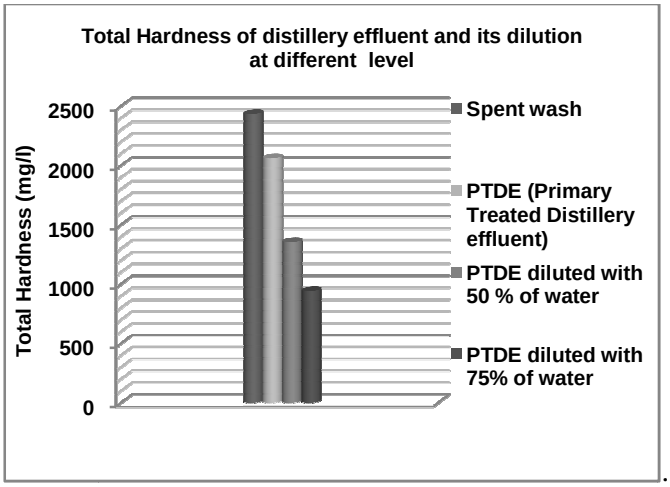

Fig. 6: Total Hardness of distillery effluent at different dilution levels

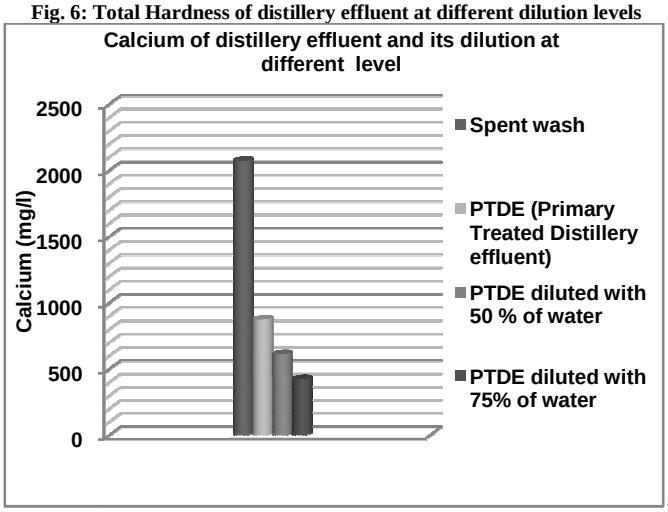

Fig. 7: Calcium content of distillery effluent at different dilution levels

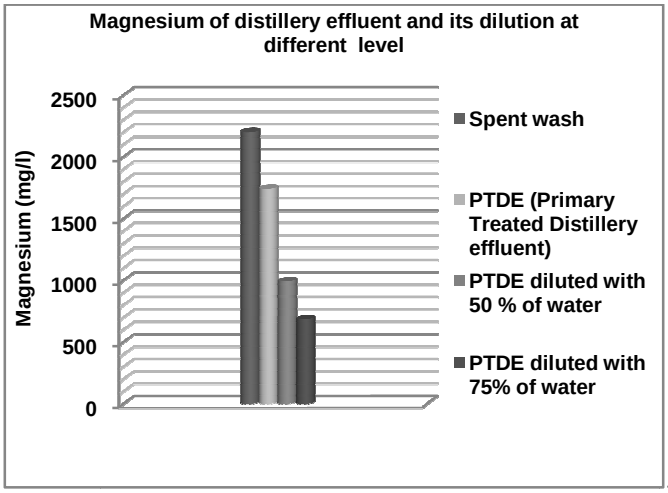

Fig. 8: Magnesium content of distillery effluent at different dilution levels

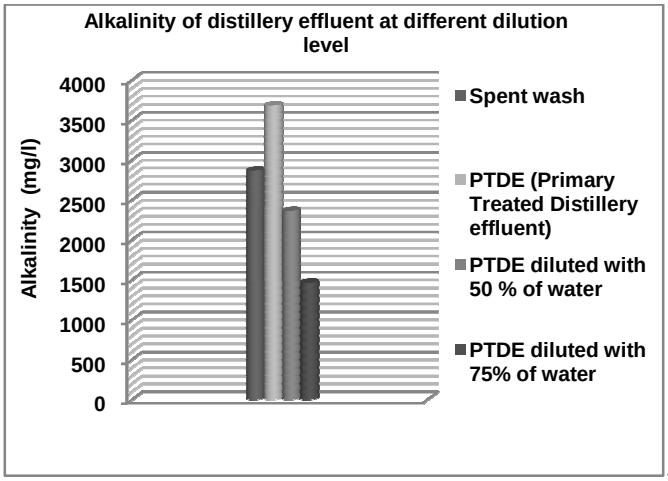

Fig. 9: Total Alkalinity of distillery effluent at different dilution levels

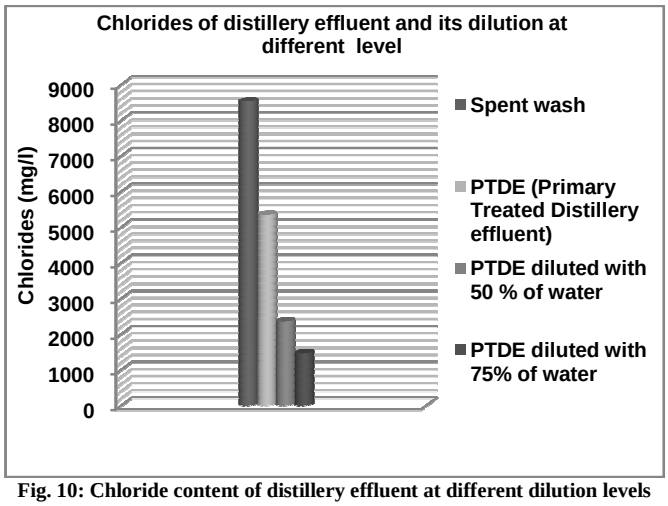

Fig. 10: Chloride content of distillery effluent at different dilution levels

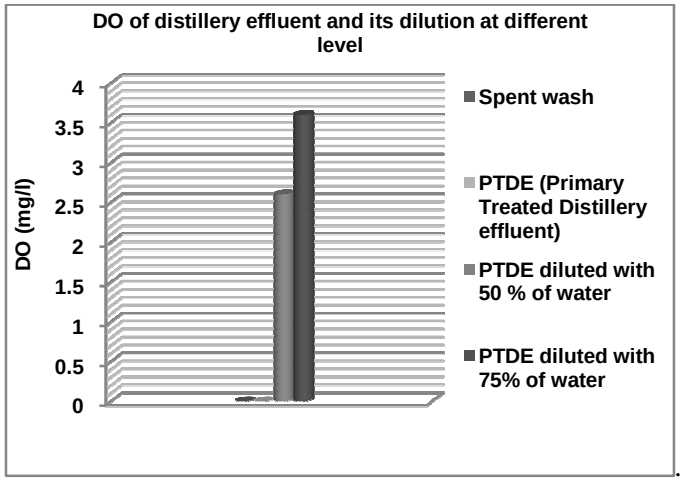

Fig. 11: DO of distillery effluent at different dilution levels

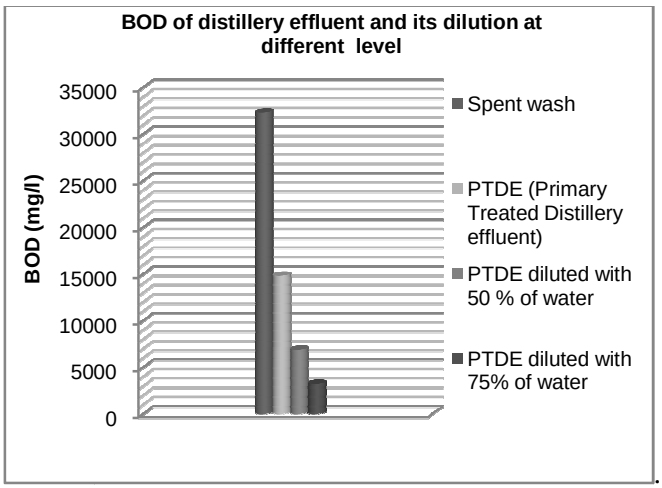

Fig. 11: BOD of distillery effluent at different dilution levels

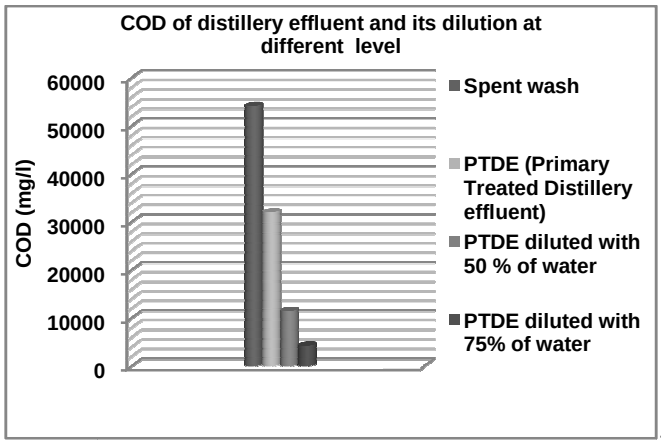

Fig.12: COD of distillery effluent at different dilution levels

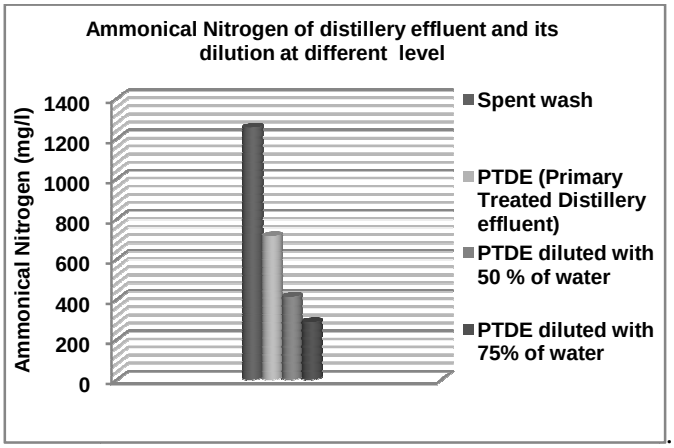

Fig. 13: Ammonical nitrogen of distillery effluent at different dilution levels

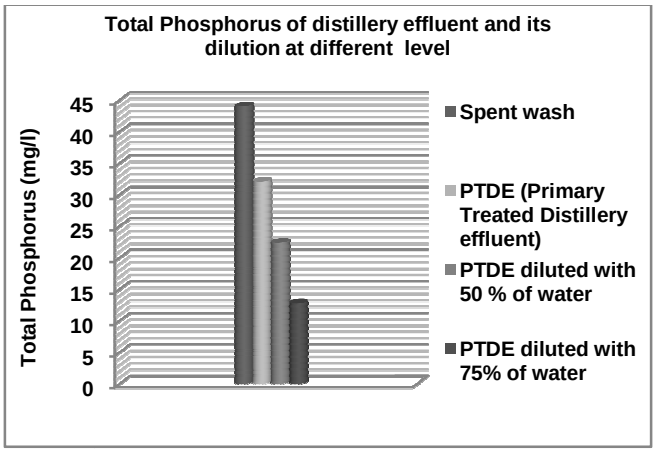

Fig. 14: Total phosphorus of distillery effluent at different dilution levels

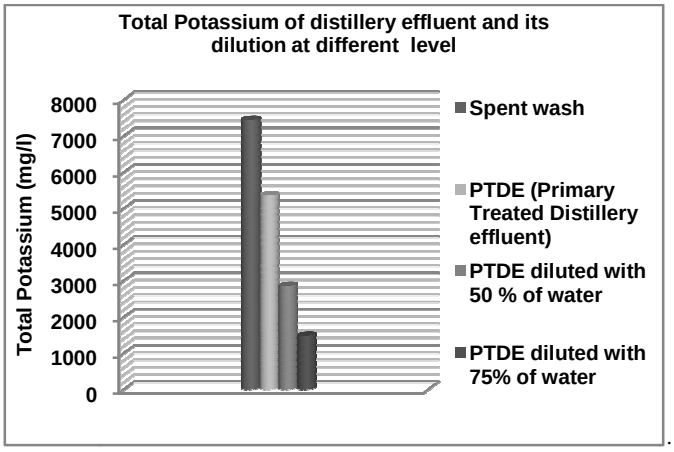

Fig. 15: Total potassium of distillery effluent at different dilution levels

Biological Oxygen Demand

The biological oxygen demand of the spent wash was very high as 32300.8 mg/l. The B.O.D. content of distillery effluent at different dilution levels was 14824.2 mg/l, 6890.5 mg/l and 3240.8 mg/l at PTDE, PTDE diluted with

50% of water and PTDE diluted with 75% of water respectively. The value of BOD decreased with increasing dilution.

Chemical Oxygen Demand
The chemical oxygen demand of the spent wash was very high as 54164.6 mg/l. The C.O.D. content of distillery effluent at different dilution levels was 32030.2 mg/l, 11448.6 mg/l and 4254.8 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Ammonical Nitrogen
The ammonical nitrogen of the spent wash was 1254.4 mg/l. Similarly result reported that the spent wash contains a very high content of organic nitrogen and nutrients **(23)**. The ammonical nitrogen of distillery effluent at different dilution levels was 714.2 mg/l, 412.3 mg/l and 286.6 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Total Phosphorus
The total phosphorus of the spent wash was 44.4 mg/l. The total phosphorus of distillery effluent at different dilution levels was 32.8 mg/l, 22.4 mg/l and 12.8 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

Total Potassium
The total potassium of the spent wash was very high as 7440.2 mg/l. The total potassium content of distillery effluent at different dilution levels was 5360.8 mg/l, 2854.2 mg/l and 1482.0 mg/l at PTDE, PTDE diluted with 50% of water and PTDE diluted with 75% of water respectively.

CONCLUSION

The study reveals that the physicochemical characteristics of spent wash and PTDE (primary treated distillery effluent) have high load of pollutants. The effluent was reddish brown in colour. Odour of samples was alcoholic in nature. It is one of the most complex and cumbersome waste having very high value of solids, electrical conductivity, hardness, calcium and magnesium compounds, chlorides, BOD and COD content and highly acidic pH, while D.O. was found Nil and contains high organic load of nutrient elements such as nitrogen, potassium and phosphorus. When PTDE was diluted with 50% and 75% of water, all the values of physicochemical properties were decreased. The decrease in these values show that the toxicity of distillery effluent decreases with increasing dilution. Thus the characteristics of spent wash and PTDE do not allow its discharge into a water body, hence it requires treatment and dilution before discharge.

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