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Impacts of Evaporation Ponds of Ethanol Distillery Spent Wash on Underground Water

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ABSTRACT
This preliminary study was designed to monitor the effect of distillery spent wash evaporation ponds on underground water. The water samples (3 spent wash and 32 underground (total 35)) were analyzed for the parameters, pH, Electrical conductivity (E.C), Total dissolved salts (TDS), Total hardness (TH), Chloride, Total phosphate-P, M-alkalinity, Sulfate, Nitrate-N, Dissolved Oxygen (DO) and Chemical Oxygen Demand (COD). The physico-chemical parameters of the water samples for spent wash and underground were found in the following ranges; pH 7.2-7.7 & 6.8-7.7, electrical conductivity 38.2-44.7 ms/cm & 0.47-32.0 ms/cm, TDS 24448-28608 mg/l & 302-19840 mg/l, Total hardness 17400-18000 mg/l & 170-4150 mg/l, chlorides 7446-13293.5 mg/l & 85.0-2836 mg/l , Total phosphate-p 229.5-328.5 mg/l & 0.005-2.29 mg/l, Methyl red Alkalinity 1702.5-2352.5 mg/l & 115-657.5 mg/l , Sulfate 3157.8-3552.6 mg/l & 10-417.1 mg/l, Nitrate-N 471.5-539.1 mg/l & 0.0-28.0 mg/l, COD 20080-24320 mg/l & 0.0-53.0 mg/l, DO 0.036-0.12 mg/l & 1.1-7.7 mg/l respectively. The underground water was observed being affected by the spent wash. It was observed that the distillery industry discharges various pollutants in concentration above NEQS for industrial effluents. Greater concentration of these pollutants is responsible for underground water pollution of study area.

Keywords: ponds, evaporation, distillery, ethanol

1. INTRODUCTION
The district Rahim Yar Khan lies between 270 -40' to 290 -16' north latitudes and 600 -45' to 700 -01' east longitudes. The total population of the district was 3,141,053 as enumerated in March, 1998 with an intercensal percentage increase of 70.6.Since March, 1981 when it was 1,841,451 souls. The average annual growth rate was 3.2 percent during this period. The total area of the district is 11,880 square kilometers and gives population density of 264 persons per square kilometer as against 155 persons observed in 1981 indicating a fast growth rate of the district.

District Rahim Yar Khan has a very hot and dry climate in summer. The maximum temperature touches 49.7^{0}C. The minimum temperature recorded is 6.8^{0}C. The average annual rainfall in the district is 165 mm. The soil of the area is sandy loam and has more percolation ability. The district can be divided into three main parts, riverain area, the canal irrigated area and the Cholistan area. The riverain area of the district lies close to the river Indus and Panjnad River. To the South West of this area lies the canal irrigated area. The land in this area is elevated than that of the riverain area. The approximate height of this area is 150 to 200 meters above sea level. The desert area lies in the South-East of the district. It is called as the Cholistan. It extends into Bahawalpur and Bahawalnagar districts, occupying the South-Eastern part of the district.

Environment is the sum of all social, economical, biological and physical or chemical factors which constitute the surroundings of men. In modern world the water bodies are being polluted by industrial wastes containing synthetic chemicals and toxic heavy metals. The soil is another victim of polluting agents released by industries[1] The effect of sugar industry on surface water have been reported by so many workers in different parts of the world[1,3]. Total registered industries in Pakistan are 6634. In rural areas the use of industrial and sewage water for irrigation causes water and soil pollution[4]. Industrial effluents damage physico-chemical parameters of ground water[5]. The effluents of sugar industry rich in organic material cause deterioration of ground water[6]. Sugar industry is main source of water pollution due to presence of number of pollutants like total hardness, total dissolved salts, biological oxygen demand and chemical oxygen demand into their wastes[7]. These pollutants not only damage the quality of receiving water bodies but also damage the quality of soil and crops irrigated on that waste[8]. Rapid industrialization without proper check and treatment of its waste puts harmful effects on the environment of its surroundings. These industries exit their wastes into natural environment especially surface water. The toxic materials discharged by the Industries enter into food chain through soil and irrigation water and causes health complications to the human[9].

Human activities are responsible for the pollution of rivers, lakes and ponds. Various researchers have studied toxicity in terms of pH, chloride, fluoride, sulfates, sodium, potassium and heavy metals in municipal and industrial effluents[10]. The spent wash contains greater amount of organic and in organic substances, can cause adverse effects to environment and human health[11]. A distillery having capacity of 30,000 liters of alcohol per day release 15 to 16 liters of effluent for single liter of alcohol. Distillery effluent is more complex due to high biological oxygen demand and oxygen demand is one of the major pollutants of ecosystem. Discharge of partially or non treated effluent in water bodies or disposal on soil surface will cause death of aquatic life as well as changes in soil composition[11].

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Industrialization is big threat to environment, effluent of sugar industry has high total hardness, and total dissolved solids biological oxygen demand, magnesium, sodium and sulfates which have adverse effects on plant growth and soil properties[1]. Industrial non treated effluents deteriorate surface and subsoil water (AKIF, 2002).Liquid waste generated by distilleries is called spent wash.61% ethanol is produced from sugar cane crop worldwide. Due to high organic and inorganic contents, it causes eutrophication of water bodies[14]. According to recent research, distillery effluent released on soil surface, contaminate ground water1[15]. Due to high salt contents, spent wash retard seed germination and plant growth. Ground water quality change due to percolation of sugar industrial effluent released on soil surface[16]. Ground water is used for industrial, domestic and irrigation purposes worldwide, according to world health organization 80% diseases in human being are due to contaminated water[17]. Present preliminary study was aimed to check the harmful effects of evaporation ponds of distillery spent wash on underground water.

2. EXPERIMENTAL

2.1 *Sampling and Methodology*

The study area is located about fourteen kilometers south of Sahibabad and forty kilometer south west of RahimYar Khan City near Manthar town. Study area is shown in Table.1a

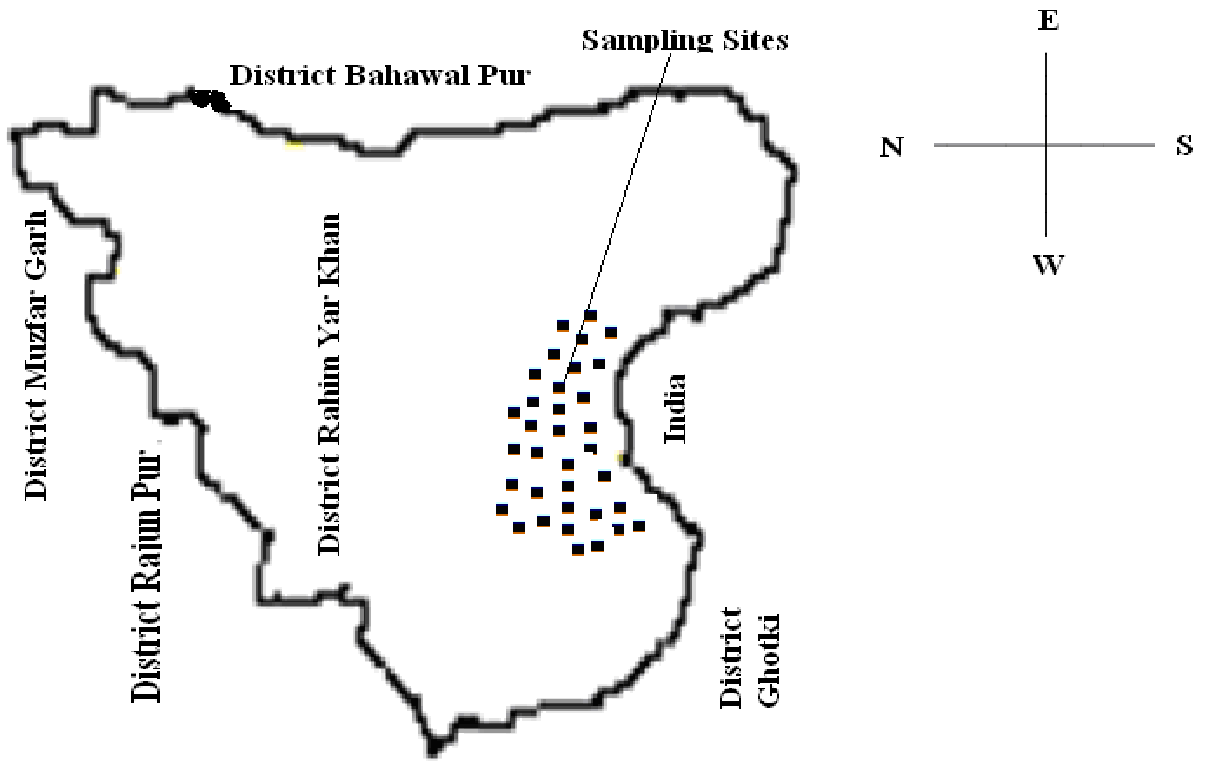

Fig-1: Map of District Rahimyar Khan, Doted area is the sampling area.

No other industrial unit except distillery exists in study area. This industrial unit produces 143000 liters of ethanol and 2145000 liters of spent wash daily. Ground water at thirty feet depth. Plastic bottles of capacity two liters were used to collect the samples. The samples were collected during the year 2008-2009,(0ctober to December) and an average value of three times sampling was measured for each parameter .The temperature of air and water was measured on the sampling spot with mercury thermometer. Hardness, chloride and alkalinity were determined by titration with standard E.D.T.A, silver nitrate and hydrochloric acid respectively. Dissolved oxygen, Conductivity, Salinity and total dissolved solids (TDS) were evaluated with Orion 115 Star conductivity meter. The pH was recorded with Orion 420 A pH meter probe. Nitrate-N was determined by brucine method. Sulfate was determined by turbidimetery as BaSO4 using Hitachi220 A spectrophotometer. Acid hydrolysable phosphate phosphorus was estimated by persulphate acid digestion method. All parameters were analyzed by standard procedure mentioned in APHA (1995)[18].

3. RESULTS AND DISCUSSION

Liquid waste generated by the industries is big source of surface and groundwater pollution. Spent wash and ground water samples were analyzed for physico-chemical parameters like pH, conductivity, total dissolved solids, sulfatetotal hardness, chloride, total phosphate-P, nitrate-N and COD. To evaluate the pollution contents the results were compared with National Environmental Quality Standard (NEQS) for industrial effluent and WHO standard for drinking water. The data on mean values of physico- chemicals characteristics is summarized in table (1). 35water samples were collected during the study year 2008-2009, three (S1-S3) were spent wash samples taken from evaporation pond near united ethanol industries Sadiq Abad as well as the ponds one and half kilometer away from factory, where effluent is transferred through underground pipe line and rough water courses. The remaining 32 samples were underground water and drainage water(26&27) samples. Groundwater samples were taken from vicinity of evaporation ponds.

3.1 *pH*

All the samples either spent wash or underground water have pH within limits of National Environmental Quality Standard for industrial effluent and WHO standard for drinking water. The pH for spent wash and groundwater samples ranged between 7.2-7.7 & 6.8-7.7respectively.

3.2 *Total Dissolved Salts (TDS) and Electrical Conductivity (EC)*

Minerals, salts, metals, cations or anions dissolved in water are referred as total dissolved salts (TDS). Inorganic salts are mainly calcium, magnesium, potassium, sodium, bicarbonate, chlorides and sulfates. Greater amount of dissolved salts increases turbidity and EC[19].TDS and EC of all spent wash samples was very high, TDS was in the range of 24448-28608 mg/l shown in Table 1a.

Sample S3 has Maximum TDS, as it receives effluent when it is discharged from the industry, while remaining spent wash samples have less value of TDS. All spent wash samples have higher values of TDSthan NEQS (3500 mg/l) of industrial effluent. TDS values for groundwater samples were in the range of 302 to 19840 mg/L including (drainage water)samples(S26 S27). These two samples were taken from the (drainage water)which carry SCARP tube wells poured water and their water is not affected by the spent so these samples have greater concentration of salts and less chemical oxygen demand.52% of the groundwater samples have TDS values above the limits of WHO for drinking water, while 48% are within limits(500 mg/l**)**.Conductivity of the spent wash samples was in the range of 38.2 ms/cm to 44.7 ms/cm. High TDS gives mineral taste to water, affects physiological functioning of plants and animals, corrosion of metallic surfaces, death of aquatic organisms due to dehydration.

3.3 *Total Hardness (TH)*

Total hardness amounts for total concentration of calcium and magnesium ions expressed as $CaCO_{3.}$ Spent wash samples showed high values of hardness. Excessive hardness may cause dehydration, kidney stone, cardiovascular diseases and diarrhea. Total hardness of the spent wash samples ranged from 2300 to 3500 mg/l (Table 1a).

Groundwater and drainage water samples which are not used for drinking purposes, have TH ranging between 80 and 1400 mg /l . Out of 32 groundwater samples, 04 were above the limit of WHO for drinking water(500mg/l).

3.4 *Total Phosphate-P*

It is found in water as soluble or insoluble phosphate and is essential for plants and animals growth. Phosphate exist in three forms, ortho- phosphate, polyphosphate and organic phosphate. The phosphate in water may be due to human activities and geological reason. The spent wash samples have total phosphate-P in the range of 2295 -3285 mg/l , minimum value of total phosphate-P was found in S1 (2295 mg/l), while maximum (3285mg/l) was detected in S3 sample (fig.2).All the spent wash samples have high contents of total phosphate-P. The amount of total phosphate-p in groundwater samples was ranged from 0.005 mg/l to 2.29 mg/l. Greater amount of total phosphate-P may cause gastric problem in human and eutrophication of water bodies. All groundwater samples were within limit of WHO for phosphate (5mg/l).

3.5 *M-Alkalinity*

Quantitative capacity to neutralize stronger acids due to hydroxides,   carbonates and bicarbonates is known as alkalinity. Alkalinity of spent wash samples ranged from 1702.5 mg/l to 2352.5 mg/l (Fig.2) and that of ground water from 115 mg/l to 667.5 mg/l calculated as CaCO3. Minimum alkalinity (115 mg/l) was noted in sample (S-31), while maximum 657.5 mg/l was found in the sample S6. Greater alkalinity may cause excessive drying of skin and remove normal skin oil.

3.6 *Chemical Oxygen Demand (COD)*

Chemical oxygen demand is total organic contents expressed in terms of the amount of oxygen required to bring about its destruction through oxidation. COD for spent wash samples was in the range of 20080 mg/l-24320 mg/l 24320 mg/l shown in Table 1a.

Table-1a: Mean values of physico- chemical parameters in spent wash and ground water samples 1-35

Sample Code	pH	EC ms/cm	TDS mg/l	*TH mg/l*	Chloride mg/l	T. Phosphate mg/l	M. Alkalinity mg/l	Sulfate mg/l	NO3-N mg/l	COD mg/l
S1	7.7	38.2	24448	3500	2230	2295.0	7200	3157.8	471.5	20080
S2	7.2	43.7	27998	2300	1813	2520.0	8600	3552.6	539.15	24320
S3	7.4	44.7	28608	2900	2313	3285.0	7600	3368.4	520.15	22720
S4	7.1	1.43	908.9	190	182.5	0.10	365.2	88.6	8.6	30.4
S5	6.9	1.696	1085	160	198.5	0.33	338.75	344.7	20.4	49.0
S6	6.9	3.31	2118.5	130	455.5	2.295	657.5	417.1	28.05	53.0
S7	7.2	1.369	876	170	131.1	0.005	275	79.7	6.9	15.4
S8	7.0	1.288	824.5	180	147	0.055	426.25	64.7	0.435	15.4
S9	7.0	4.1	2624	230	1389.6	0.05	372.5	44.7	5.9	10.0
S10	7.3	1.1	704	320	233.9	0.08	185	24.9	8.4	20.8
S11	7.0	1.6	1024.5	160	168.3	0.1	395	108.9	30.5	10.8
S12	7.0	1.675	1072	310	180.75	0.02	407.5	105.9	12.98	30.4
S13	6.8	1.955	1231	202	209.1	0.9	547.5	109.7	114.9	50.4
S14	7.1	3.07	1964.5	460	283.65	0.03	385	119.4	7.2	20.8
S15	7.2	3.5	1892.5	230	529.95	0.06	380	126.0	14.3	20.5
S16	6.9	5.4	3917	630	428.9	0.19	382	159.2	13.7	36.1
S17	7.2	2.014	787	320	297.7	0.22	275	131.5	19.2	30.8
S18	7.4	2.575	1262	450	368.6	0.009	317.5	136.8	13.8	30.6
S19	6.9	4.5	2227	380	290.6	0.18	517.5	117.8	2.6	30.4
S20	6.9	3.48	1965	640	301.2	0.06	268	163.1	12.75	31.2
S21	6.9	6.91	4406	260	1210	0.1	600	142.1	2.3	30.4
S22	7.1	2.635	1687	230	836.6	0.11	476.5	116.3	10.5	10.4
S23	7.3	0.89	560	380	212.7	0.13	240	63.1	2.5	10.4
S24	7.0	1.302	833	320	184.2	0.05	355	78.9	1.5	10.0
S25	7.4	0.82	515	270	226.8	0.08	150	40.5	0.01	10
S26	7.4	32.0	19840	1400	2836	0.009	4012	147.3	0.01	10
S27	7.2	32.0	19840	1390	2712.5	0.02	4443	142.1	0.01	10
S28	7.7	0.681	436	110	92.1	0.03	202.5	75.7	0.0	10.8
S29	7.6	0.917	587	101	148.8	0.05	155	28.9	1.9	10.8
S30	7.7	0.47	302	96	85.0	0.009	115	28.4	2.3	0.0
S31	7.3	0.508	320	80	77.9	0.01	163	46.8	2.3	10.4
S32	7.5	0.632	401	95	177.2	0.008	190	10	7.7	0.0
S33	7.0	1.31	842	112	148.8	0.07	200	70	6.3	10.4
S34	7.0	1.123	720	103	113.4	0.07	195	66.3	9.8	10.4
S35	6.9	3.155	2018	342	331.4	0.0145	380.5	156.0	17	30.4

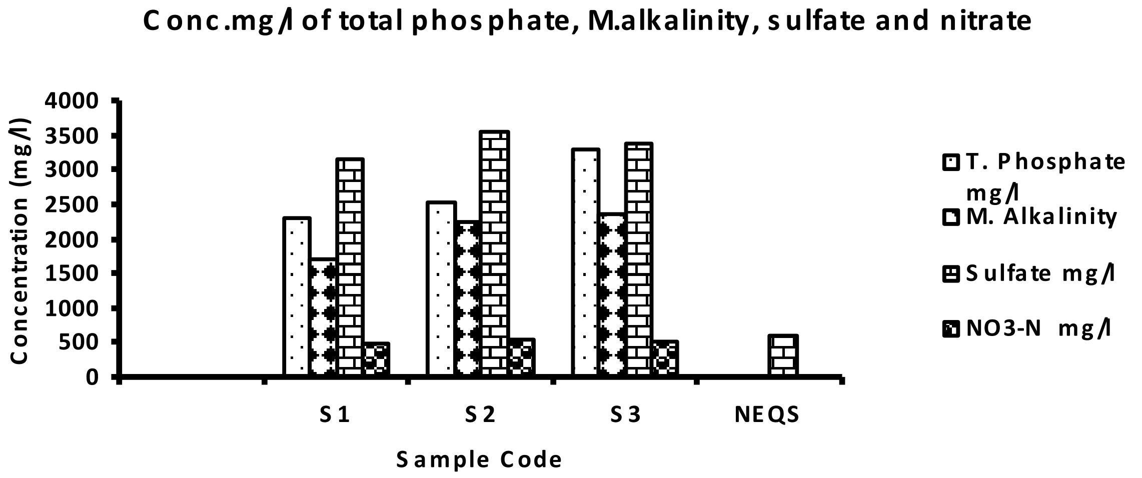

Fig-2: Concentration in mg/l of total phosphate-P, M. alkalinity, sulfate and nitrate in spent wash samples

Table-1b: Mean values of physico- chemical parameters in spent wash and groundwater sample

S.No	Na mg/l	k mg/l	Camg/l	Mg mg/l	SAR	S.No	Namg/l	Kmg/l	Camg/l	Mgmg/l	SAR
S1	1449	2067	822	728.4	12.4	S19	418.6	20.67	92	7.2	15.9
S2	2753.1	2090.4	688	363.6	29.7	S20	568.1	20.67	272	12	12.8
S3	1706.6	2067	414	728.4	16.4	S21	929.2	20.67	84	18	33.7
S4	278.3	17.55	42	16.8	12.8	S22	788.9	20.67	44	15.6	36.5
S5	368	20.67	40	8.4	19.4	S23	469.2	13.26	64	2.4	22.0
S6	519.8	20.67	22	16.8	28.1	S24	388.7	10.14	52	9.6	18.2
S7	230	16.38	42	12.72	11.2	S25	508.3	7.41	36	7.2	28.4
S8	308.2	20.67	28	13.2	16.8	S26	1869.9	20.67	484	67.2	29.7
S9	908.5	14.04	88	18	32.4	S27	1828.5	20.67	470	68.4	29.3
S10	379.5	15.6	30	8.4	22.1	S28	128.8	12.48	28	7.2	7.8
S11	289.8	5.85	32	13.2	15.2	S29	269.1	4.68	30	7.2	16.1
S12	319.7	8.97	70	9.6	13.3	S30	167.9	4.29	22	6	11.5
S13	349.6	17.55	44	12	16.9	S31	119.6	5.07	20	8.4	7.9
S14	469.2	33.54	104	19.2	15.6	S32	308.2	7.02	24	6	20.5
S15	609.5	19.89	28	15.6	31.8	S33	289.8	21.06	28	6	18.2
S16	519.8	18.72	186	26.4	13.3	S34	239.2	11.31	20	3.6	18.2
S17	409.4	20.67	80	18	15.1	S35	920	20.67	38	7.2	49.9
S18	627.9	20.67	60	4.8	29.5						

Table-2: WHO standards for ground water and EPA standard for industrial effluents

Contaminants	WHO standard for ground water	NEQS for industrial effluents
pH	6.5-9.2	6-10
Total Dissolved Solids mg/l	500	3500
Chloride mg/l	250	1000
Fluoride mg/l	1.5	20
Sulfate mg/l	200-400	600
Chemical Oxygen Demand mg/l	10	150
Phosphate mg/l	5	N.A
Nitrate mg/l	45	N.A

NA = not available

All the spent wash samples have high chemical oxygen demand then prescribed limit of National Environmental Quality Standard (NEQS) (150 mg/l) for industrial effluents. COD of groundwater samples was ranged from below the detection limits (BDL) to 53.0 mg/l. The samples closer to the ponds have greater COD values. Out of 32 ground water samples, 17 samples indicated COD above the limit of WHO (10 mg/l) for drinking water. Elevated level of COD in soil and water consumes oxygen. Deficiency of oxygen in soil retard root growth, low oxygen in water bodies due to high COD cause death of aquatic life fig. 3

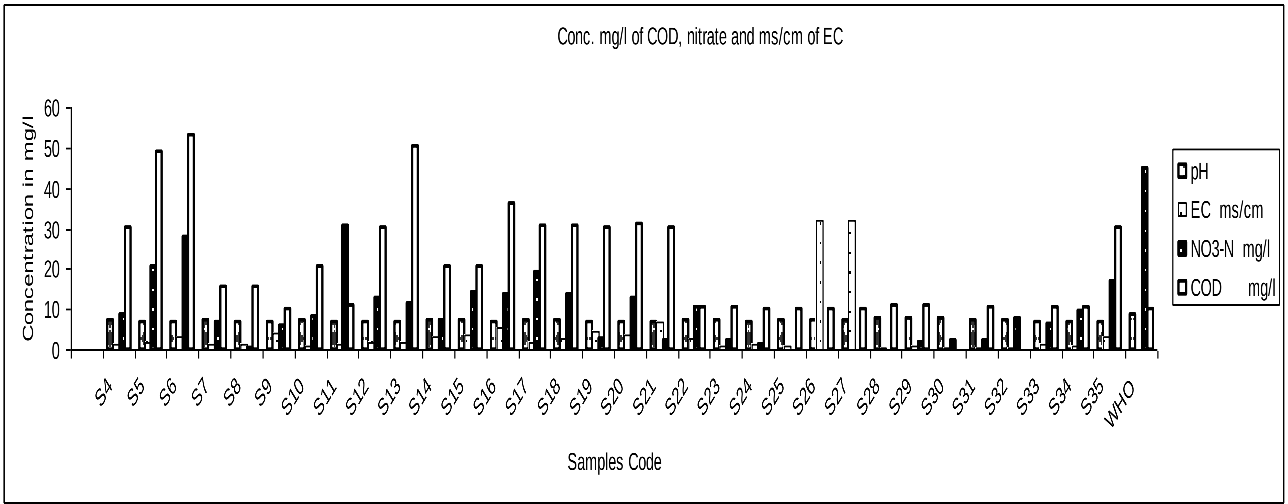

Fig-3: Concentration in mg/l of COD, nitrate and ms/cm of EC of water samples.

3.7 *Sulfates*

Sources of sulfate in surface and subsurface water are mainly calcium sulfate and sodium sulfate the sulfate concentration in spent wash samples was ranged between 3155.7 mg/l and 3552.6 mg/l. Maximum sulfate (3552.6 mg/l) was found in the sample S2, while minimum (3157.5 mg/l) was found in the sample S1. The sulfate contents in groundwater samples ranged from 10 mg/l to 417.1 mg/l shown in Fig.4

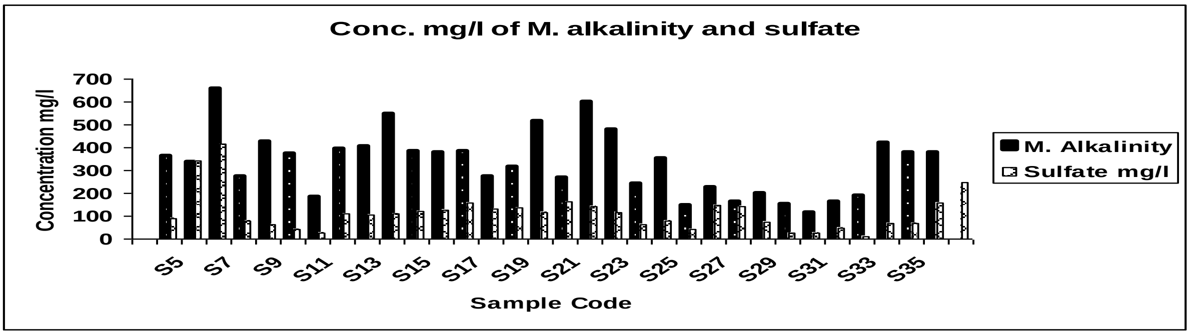

Fig.4-: Conc. in mg/l of M. alkalinity and sulfate in ground water samples

The ground water sample (S6) indicated maximum sulfate contents; this sample was taken near underground pipe line carrying spent wash towards water courses. High contents of the sulfates may be due to spent wash or fertilizers used for agricultural purpose. Sulfate has laxative effect and imparts unpleasant taste to water. Two groundwater samples had excessive concentration of sulfate than prescribed limit (250 mg/l) of WHO, while remaining groundwater samples were within limit.

3.8 *Nitrate-N*

Nitrates and nitrites are nitrogen-oxygen chemical units, once the nitrates are taken in to the body they are converted in to nitrites. Inorganic nitrates, which contaminate drinking water are potassium nitrate and ammonium nitrate, which are used in fertilizers. Nitrogenous material in natural water is converted to nitrate. Protein rich organic matter is considered potential source of nitrates.

Excessive nitrates in drinking water may cause illness and death, Mathemoglobinemia, starch deposition, hemorrhage of spleen, enlargement of thyroid, fifteen types of cancers, two type of birth defects, stomach cancer and eutrophication[20]. Nitrate concentration in spent wash samples was from 471.5 mg/l to 531.1 mg/l and in groundwater samples were below the detection limits (BDL) to 28.0 mg/l shown in Fig.3. All drinking water samples have nitrate concentration below the prescribed limit of WHO (45 mg/l) for drinking water Table.2

3.9*Metal ion contents (MIC)*

The concentration of essential metals Na, K, Ca and Mg varied in spent wash and groundwater samples Na being dominant in spent wash and groundwater (Table-1b) in the order Na > K >Ca>Mg in spent wash and Na >Ca> Mg > K in groundwater. Na was ranged 1449-2753.1 mg/l ; K 2067- 2090.4 mg/l; Ca 414-822 mg/l; and Mg 363.6-738.4 mg/l while in groundwater Na 119.9 - 1869.9 mg/l; Ca 20- 484 mg/l; Mg 2.4-68.4 mg/l and K 4.29- 33.54 mg/l Table 1b.

3.10 *The contamination index C_d*

The contamination index was calculated by following equation

$$C_d = \sum_{i=1}^{n} Cfi \quad \text{Where, } Cfi = [(CAi / CNi)-1]$$

Cfi = contamination factor for the i-th component

CAi = analytical value for the i-th component

CNi = upper permissible concentration for the i-th component

To calculate the degree of contamination for the assessment of water quality[21] developed contamination index C_d .The parameters of a particular sample exceeding upper permissible limit are calculated separately and by addition of factors C_d was obtained. The factors with in permissible limits were excluded from C_d calculation. The upper permissible limit for C_d calculation are prescribed limit of NEQS and WHO for different parameter of industrial effluents and drinking water. The C_d is combination of different parameters considered harmful for water used for domestic purpose. The results of C_d are summarized in Table 3. As all the spent wash samples have C_d>145 indicating that they are highly contaminated, while groundwater samples on the bases of observed values of C_d two samples have zero C_d values, 9 samples with less contamination C_d<1, 6 samples with intermediate contamination C_d<3. The samples with high contamination indicated the C_d values in 3.1-49.0 range, were taken closer to distillery spent wash evaporation ponds, and may indicate the effect of spent wash.

Table-3: Contamination Index (C_d)

Sample Code	Contamination Index (C_d)	Sample Code	Contamination Index (C_d)
S1	149.5	S19	5.5
S2	183.9	S20	5.8
S3	174.5	S21	13.3
S4	2.8	S22	3.1
S5	5.4	S23	0.16
S6	9.0	S24	0.6
S7	1.2	S25	0.03
S8	1.1	S26	49.0
S9	9.1	S27	48.5
S10	1.4	S28	0.08
S11	1.1	S29	0.2
S12	3.3	S30	0.0
S13	5.5	S31	0.04
S14	4.1	S32	0.0
S15	4.3	S33	0.7
S16	9.5	S34	0.4
S17	2.7	S35	5.4
S18	3.5	-	-

3.11 *Permeability Index (PI)*

The permeability index ranged 51% to142% in a hydrological year. Average value 96.7% of permeability index is above the class-1[21] making it unsuitable for cropping, while Na% categorizes 02 samples as permissible, 13 as doubtful 20 as unsuitable. None of the sample is included in excellent or suitable category (Table 4). The application of these two parameters indicated that all the samples have high values of PI and Na % also indicated high concentration of sodium which makes water unsuitable for irrigation purposes.

3.12 *Residual Sodium Carbonate (RSD)*

Was calculated by the formulae

$$\mathbf{RSC= (HCO_3^{-1}+CO_3^{-2})-(Ca^{+2}+ Mg^{+2})}$$

RSC places 9 samples in good quality having RSC less than 1.25, 4 samples having RSC in1.25-2.5 range are doubtful and remaining 22 samples are unsuitable for irrigation purposes (Table 5).

Table-4: Quality of water samples used for irrigation purposes based on Na %

Na %	Water class	Samples Code	Total NO of spenwash ground water samples
< 20	Excellent	Nil	Nil
20-40	Good	Nil	Nil
40-60	Permissible	S1,S3	02
60-80	Doubtful	S2,S4,S7,S12,S14,S16,S17,S19,S20,S26,S27,S28.S31	13
>80	Unsuitable	S5,S6,S8,S9,S10.,S11,S13,S15,S18,S21,S22,S23,S24,S25,S29,S30,S32,S33,S34,S35	20

Table 5: Classification of Irrigation Water samples on the bases of Residual Sodium Carbonate

RSC millieq/l	Water quality	Samples Code	Total No. of samples
<1.25	Good	S10,S16,S17,S23,S25,S28,S29,S30,S31	09
1.25-2.5	Doubtful	S9,S20,S32,S33	04
>2.5	Unsuitable	S1,S2,S3,S4,S5,S6,S7,S8,S11,S12,S13,S14,S15,S18,S19,S21,S22,S24,S26,S27,S35	22

Table-6: Hardness Based Classification of Spent Wash and Groundwater samples

Total Hardness	Water class	Samples Code	Representing Samples
< 75	Soft	Ni	Nil
75-150	Moderately	S6,S28,S29,S30,S31,S32,S33,S34	08
150-300	Hard	S4,S5,S7,S8,S9,S11,S13,S15,S21,S22,S25	11
>300	Very Hard	S1, S2, S3,S10,S12,S14,S16,S17,S18,S19, S20,S23,S24,S26,S27,S35	16

Table-7: Classification of Spent wash and Groundwater samples on Alkalinity Hazard bases

SAR	Alkalinity Hazard	Water Class of Sample	Sample Code	Total No.
<10	A1	Excellent	S4,S5,S6,S7,S8,S9,S10,S11,S12,S13,S14,S15,S16,S17,S18,S19,S20, S21,S22,23,S24,S25,S28-S35	30
10-18	A2	Good	Nil	
18-26	A3	Doubtful	S1,S3	02
>26	A4	Unsuitable	S2,S26,S27	03

4. CONCLUSION

This study shows that all the spent wash samples do not follow the National and International standard for industrial effluent. Discharge of spent wash into evaporation ponds or transfer through rough water courses towards evaporation ponds is polluting groundwater and soil. Spent wash storage in evaporation ponds with foul smell is responsible for air born diseases to human and animals of the area. Spent wash and ground water samples are also misfit for irrigation. Fifty percent of ground water samples exceeded WHO standard for drinking water. Some of the groundwater samples taken from the vicinity of evaporation ponds showed the effect of spent wash storage, if proper treatment and safe disposal measures will not be taken then the groundwater of the whole area will become contaminated.

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