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Assessment of Distillery Effluent on Soil Quality of Adjoining Communities- A Case Study

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Abstract: This study is conducted to evaluate the inmical impact of distillery spent wash on the soil properties. This is a quantitative study based on the physico-chemical analysis of distillery spent wash and soil. Soil and spent samples were collected from two different locations; Mirpurkhas and Tando Muhammad Khan in Sindh province, A controlled soil sample was also collected from Town Tando Qaiser, Hyderabad district, where there is no distillery operating and has farms. All the samples were analyzed with different analytical parameters and compared with Sindh Environmental Quality Standards. The testing methods were followed under standard reference methods of ASTM-2011, USEPA-2001 and APHA-2005. The analytical results have shown the chronic effect of spent wash on the soil, Electrical conductivity of district Mirpurkhas was found 92348.421µs/cm and Tando Muhammad Khan has 76375.134µs/cm, which was greater than the controlled samples EC of 18229.89µs/cm. Both distilleries have very high electrical conductivity of 171448.65µs/cm and 160314.462µs/cm respectively. Other results of spent wash and soil were also exceeding the limit of SEQs and controlled sample. The distillery spent wash has high concentration of BOD (760 mg/l, 4,120 mg/l) and COD (2,950 mg/l, 20,640 mg/l) as compared to SEQs BOD (80 mg/l) and COD (150 mg. l) for discharge of industrial effluent. Both the distilleries discharged their effluent directly into the river canal. The physical appearance of the soil was noticed to be garish black in color and stunted growths of trees indicate the excessive use of spent wash for irrigation.

Keywords: Spent wash, distillery effluents, soil quality, electrical conductivity.

Introduction

Pakistan is an emerging economical hub in the entire world regarding industrial and agricultural revolution. In the line of an agricultural division, it plays an important role in developing and exporting agro-based goods to different regions of the world. Sugar industries of Pakistan become the second largest sector having a GDP growth of 2.0% in the manufacturing sector. Approximately, 21 distilleries are operating nationwide by sugar mills having a net capacity of 2 million tons of annual production of molasses and 400,000 tons of fuel-grade ethanol per annum.

Ethanol is produced by fermentation of molasses/ sugarcane in distilleries producing wastewater called spent wash, which is typical in composition (Goel., 2015, Rath. P *et al*., 2010). The spent wash of distilleries has organic constituents, which have dark brown color (Sharma et al., 2012; Ghosh Ray et al., 2018; Wagh et al., 2015; and Chhaya et al., 2014). It is highly acidic, having pH value less than 4.0 (Shenbagavalli et al., 2011; Kumar Sindhu et al, 2007). Chemical oxygen demand (COD) and biological demand (BOD) are very high (Saha et al., 2004, Tariq Mahar et al., 2012) and it has some essential nutrients like nitrogen (N) and potassium (K) which are useful for crop cultivation.

It is estimated that one liter of ethyl alcohol is generated per 12 to 15 liter of spent wash (Prakash et al., 2014; Jamil Qureshi., 2015; Mahar et al., 2013). Spent wash is one of the major sources of soil and groundwater contamination (Thakkar, 2013; K. Sing et al., 2007; Kumar et al, 2017). Due to high BOD (35,000 to 60,000) mg/l and COD (80,000 to 1, 20,000) mg/l values, Central Pollution Control Board (CPCB) has marked it one of the most polluting industries of the world (Dave et al., 2012).

Distillery spent wash affects the soil's microorganisms, as those areas which were exposed to the distillery spent wash irrigation have created resistance to soil microorganisms (Mohana et al., 2009). About 80% of the whole distillery's spent wash, which is discharged through the sugar industries is not properly treated. Due to its physiochemical composition, it may become harmful to human health and cause loss of soil fertility, loss of interaction within livestock, agriculture and biodiversity (Anoop et al., 2014).

Distillery industries usually disposed off their liquid waste onto nearby land and water bodies (Deshmuk, 2014; Ansari et al., 2014; Terefe et al., 2015), heavy metals travel through the soil by convection, leaching and by diffusion process and contaminate it (Ansari et al., 2012). The continuous mixing of solids into the soil can cause the hydraulic conductivity to reduce

(Naves et al., 1983, Sweeney, 1991). Distillery spent wash also affects plant microorganisms. Continuous use of nitrogen fixing bacteria Rhizobium and Azotobacter decreases and fungi increases (Juwarkar and Dutta, 1990).

Table 1. Description of representative sampling locations.

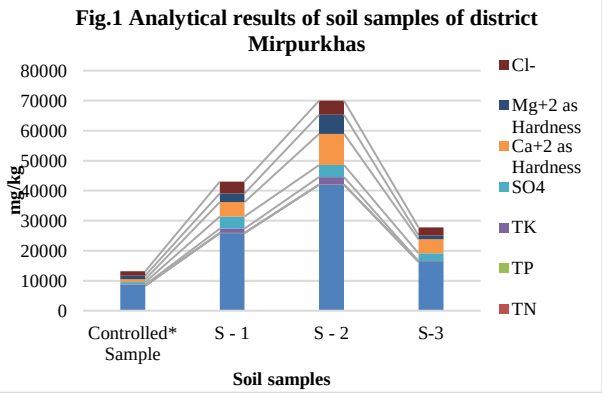
Sample	Reference no.	Sample point	Distance from distillery unit
Distillery spent wash / treated effluent primary	SW - 1	Distillery unit of Mirpurkhas district	1000 meters
Distillery spent wash / Final discharge line	SW - 2	Distillery unit of Mirpurkhas district	40 meters
Spent wash samples	SW - 3	Mill Syrup in Lagoon Tando Muhammad Khan district	430 meters
Spent wash sample	SW - 4	Factory outlet Tando Muhammad Khan district	Factory outlet
River water sample	RiW - 1	Near distillery Mirpurkhas district	570 meters
River water sample	RiW - 2	Zardari road, distillery unit near Tando Muhammad Khan district	520 meters
Soil sample	S - 1	from distillery of Mirpurkhas district	170 meters
Soil sample	S - 2	from distillery of Mirpurkhas district	240 meters
Soil sample	S - 3	Away from distillary	2.2 Kms
Soil sample	S - 3	Khas Ali Gauf, Ansari Sugar Mill Tando Muhammad Khan district	400 meters
Soil sample	S - 4	Back side of sugar mill Tando Muhammad Khan district	510 meters
Soil sample	S - 5	NisarJagssi R/o Tando Ghulam Mir Tando Muhammad Khan district	630 meters
Soil sample	Controlled Sample	From district Qaiser Town , the distance From Mirpurkhas From Tando M. Khan	67.8 kms 64.5 kms

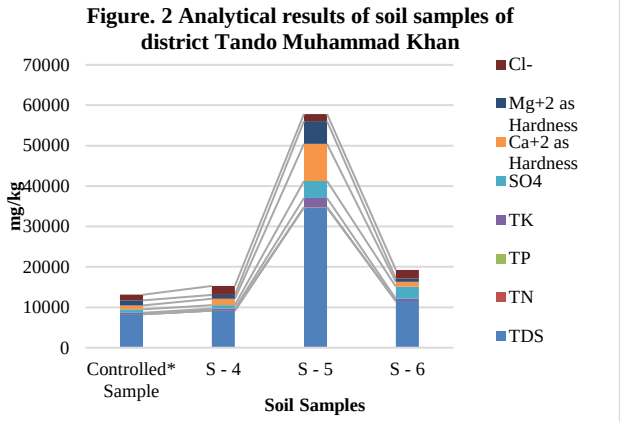
Study Area

Samples were collected from two different locations in Sindh province, where distilleries are operating for many years. First location for collection of soil and spent wash samples was taken from district Mirpurkhas that lies at coordinate axis at 25°52’50” N, 69°015’8” E. Second location was from district Tando Muhammad Khan having a coordinate axis of 25.1333° N, 68.5333° E. Also, controlled samples were collected from 13 kilometers away in Tando Qaiser town (25°23′33″N and 68°34′6″E). Hyderabad district, where there was no distillery operating. The distance between Tando Muhammad Khan and town Tando Qaiser town is about 64.5km, whereas it lies 67.8 km away from Mirpurkhas.

Materials and Methods

Physicochemical tests were analyzed by HACH Spectrophotometer UV VIS DR-2000 and Atomic Absorption Spectroscopy Model no.HIM-6000^{TM}. Sampling procedures were conducted according to APHA, 2005 and UESPA, 2001. The spent wash samples were collected from discharge line of the factory and collected in 600 ml polystyrene plastic bottles. Surface soil samples were collected from different locations near distillery unit and collected in plastic lock bags. All the samples were collected from the respective sources and stored immediately in an adiabatic icebox maintaining temperature up to 4°C. All samples were analyzed for physical and chemical parameters in the laboratories of Environmental Research Center, Bahria University, Karachi Campus.





Results and Discussion

The results of physicochemical data of spent wash and soil samples obtained through field investigations have been summarized in Tables 2,3.

Temperature is found to be uniform in all samples, where it spans between 25-28°C. The samples SW-1 and SW-3 show signs of being highly acidic in nature and exceed the limit of SEQs i.e. 6-9. Spent wash SW-3 was placed on a large open area of lagoon back side of the factory. Samples of soil near distillery S-1, S-2, S-3, S-4, S-5 and S-6 are within the limit as compared to controlled sample 7.32. Total suspended solids (TSS) of both the spent wash of district Mirpurkhas and Tando Muhammad Khan have high values as compared to SEQs limit 200 mg/l for discharge industrial effluent. TDS of spent wash SW-1(77,931.204 mg/l), SW-2 (11, 361.454 mg/l), SW-3 (22, 88,050 mg/l) and SW-4 (1, 58,940 mg/l) are very high against the SEQs limit for industrial effluent 3,500 mg/l. The distillery discharged SW-4 directly into the river canal, which has RiW-2 (2,096 mg/l). (Figs. 3, 4). Analytical results of both rivers RiW-1 and RiW-2 have shown high concentration of ions (Table 2, Figs. 3, 4). For example, in both river samples, RiW-1 and RiW-2 show iron (Fe^{+2}) concentration of 21.8 mg/l and 50.5 mg/l and iron Fe^{+2} in sample SW-2 is of the quantity 13.9 mg/l and SW-4 has 21.7 mg/l. Both river samples for iron (Fe^{+2}) does not comply the SEQs limit for discharged industrial effluent which is 8.0 mg/l. Similarly, the turbidity of both river samples is found to be 6.74 NTU and 3.31 NTU. The SEQs define the limit less than 5 NTU for drinking water quality. Soil samples S-1, S-2, S-3, S-4S-5 and S-6 indicate high concentration of ions as compared to controlled samples (Table 3). Distillery discharged spent wash SW-2 and SW-4 directly into river basin, and the analytical results of both river basins were found to be high as compared to SEQs limit for drinking water quality. The farmer's living near the distillery used this river water for irrigation purpose. All samples contain high E.C values as compared to the controlled sample. Distillery spent wash contains excess concentration of Ca^{+2} and Mg^{+2} ions. Ca^{+2} ions in both spent wash and soil samples remain very high in accordance with SEQs standards. In Tables 2, 3, Figures 1, 2, results of chemical characteristics of all samples are high with respect to SEQs limits. Experimental data reveal, the impacts of spent wash on nearby soil quality as compared to controlled samples. Due to high rate of leaching and seepage of spent wash and overloading with the organic and inorganic matters, distilleries' effluents create a harmful effect on soil quality nearby.

Table 2. Physiochemical analysis of spent wash and river water samples.

S#	Parameters	Unit	SEQs** * Limit	District Mirpurkhas			District Tando Muhammad Khan		
				SW - 1*	**SW - 2****	**RiW -1**	**SW - 3***	**SW - 4****	**RiW - 2**
1	Temp	°C	40	25.4	25.7	26.6	26.7	26.9	26.5
2	pH	pH	6 - 9	3.74(1: 50)	6.34(1: 10)	7.22	3.83(1:10)	6.09 (1:10)	7.17
3	TSS	mg / l	200	14161	948	87.0	152750	10270	62.0
4	TDS	mg / l	3500	77931.204	11361.454	6247.734	72870.211	31030.503	5299.029
5	BOD	mg / l	80	33640	760	---	42,800	4120	---
6	COD	mg / l	150	78910	2950	---	92740	20640	---
7	E.C	µs /cm	NoGL	171448.65	24995.20	13754.016	160314.462	68267.106	11657.866
8	NO_3	mg / l	NoGL	780	7.0	0.5	160	2070	2.1
9	PO_4	mg / l	NoGL	47.9	10.1	0.31	48.5	82	0.21
10	SO_4	mg / l	600	1080	1020	60	9200	800	540
11	Ca^{+2} as Hardness	mg / l	NoGL	13200	3200	2400	2000	1600	1400
12	Mg^{+2} as Hardness	mg / l	NoGL	8057.94	1953.44	1465.08	1220.9	976.72	854.63
13	Cl^-	mg / l	1000	28080	1368	216	35280	15120	684
14	Fe^{+2}	mg / l	2.0	515	13.9	21.8	466	21.7	50.5
15	Cu^{+2}	mg / l	1.0	189	1.73	1.35	201	16.4	1.22
16	Cr^{-2}	mg / l	1.0	4.2	0.035	0.016	3.6	0.17	0.008
17	Cd	mg / l	0.1	BDL	BDL	0.0088	BDL	0.012	BDL
18	Ni	mg / l	1.0	BDL	BDL	0.02093	0.02424	BDL	0.01864
20	P_b	mg / l	0.5	0.09643	0.09774	0.0708	0.0116	BDL	BDL
21	Oil &Grease	mg / l	10	36,920	29,320	---	2,14760	43,380	---

* **SW – 1**&**SW - 3** are the primary treated effluent. **SW - 3**sample is mill syrup which was collected from open lagoon after being discharged by an industry in open land. **SW - 3** was considered as anuntreated effluent having reddish brown color.
** **SW – 2**&**SW - 4** were considered as a treated effluent, which was discharged by an industry into the flood basin. **SW - 2** is diluted to (1: 10) before final discharge in accordance with the company management.
*** **SEQS** Sindh Environmental Quality Standard, the Sindh Govt. Gazette, Part – 1 Ext. jan.28, 2017 for wastewater quality.

Conclusion

The surrounding area of the distillery is an irrigation land, which is spread in large acres. The farmers near the distillery use land for sugarcane cultivation. But during the survey, it was noticed that physical

appearance of soil was found to be grayish black color, coagulating dry hard, silty clay and massive shape, which was spread in large acres across the distillery and flora on that area was dead and their leaves and stems were of yellowish black color. It was also clearly seen that the land had a grayish black color and the soil was found to be infertile. There was also stunted growth of plant on dead land and black leaves were seen as compared to the land having brownish color with the use of tress and crops.

Table 3. Analytical results of soil samples.

S#	Parameters	Units	Controlled* Sample	District Mirpurkhas			District Tando Muhammad Khan		
				S - 1	**S - 2**	**S - 3**	**S - 4**	**S - 5**	**S - 6**
1	Temp	°C	27.9	26.4	26.3	26.4	28.2	28.2	26.1
2	pH	pH	7.32	7.92	8.11	8.02	7.52	7.13	7.82
3	TDS	mg/kg	8286.31	25843.23	41976.55	16,302.11	9175.137	34715.97	11542.627
4	Salinity	‰	0.3	0.6	1.8	0.6	0.4	0.5	0.1
5	E.C	µs/cm	18229.89	56855.10	92348.42	35864.64	20185.301	76375.134	25393.779
6	T_N	mg/kg	17	39	48	21	22	43	0.5
7	T_P	mg/kg	0.34	78	10.8	6.3	3.41	0.26	0.45
8	T_K	mg/kg	341.52	1421.66	2496.89	195.83	423.938	2282.24	593.0448
9	SO_4	mg/kg	847	4000	4000	2608.3	900	4200	3000
10	Ca^{+2} as Hardness	mg/kg	980	4800	10400	4694.4	1600	9200	1200
11	Mg^{+2} as Hardness	mg/kg	1242	2930.16	6348.68	1273.6	976.72	5616.14	732.54
12	Cl^-	mg/kg	1400	3960	4680	2634	2160	1800	2160

According to the farmers, earlier they used distillery spent wash for crop cultivation, they got high yield of the crops. But, as time passed, it was noticed that crop production reduced and it finally became zero. Now they have left their infertile land and avoid distillery spent wash to avoid further damage.

Present study revealed that distillery spent wash has a chronic impact on the soil. Spent wash is directly discharged through the industry and has a high value of BOD_5, COD, TDS, TSS, EC, Fe, Mg^{+2}, Ca^{+2}, oil and grease, SO_4^{-2}, NO_2^{-2}, PO_4, Cu and Cr as compared with the SEQs limit, which alter the physical and chemical characteristics of the soil. The samples SW-1 and SW-3 discharged into the open land, which is spread over large acres of land. It may create the high risk of ions to percolate into the groundwater.

It is concluded that spent wash is rich with pollutants, which cause a threat to the environment. It is necessary to treat the spent wash before releasing from the distillery. Many technologies have been developed like Post Methanated Distillery Spent Wash (PMDSW), Nano filtration by reverse osmosis method, an-aerobic digestion and wet oxidation processes, which are effective and less expensive methods for the treatment of spent wash. Moreover, the spent wash has essential nutrients like phosphate, potassium and calcium. This is beneficial for plant growth. Several researches have been conducted on the use of distillery spent wash for irrigation on land. The dilution methods like 1:20 and 1:50 are very effective ratios which were considered. The farmers should not use spent wash on regular basis.

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