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PHYSICOCHEMICAL CHARACTERISTICS OF PRODUCED WATER FROM DAKHNI OIL FIELD, PUNJAB, PAKISTAN AND ITS EFFECT ON SURROUNDING SOIL

Abstract:

Present study was conducted to analyse the physio-chemical parameters of produced water of Dakni oil field, Punjab, Pakistan and their effects on surrounding soils. Some of the parameters were analysed on the spots and rest were analysed in the Laboratory by using standard methods. The results of physical parameters of produced water i.e. pH and TDS were ranged from 5.5-7.5 and 2620-82600 mg/l, respectively. According to Pak-EPA standards pH of produced water lies within the defined limits and TDS is much higher than the limit defined by pak-EPA. Results of ion analysis in produced water samples indicate that levels of sodium (Na), potassium (K), calcium (Ca), megnisium (Mg), floride (F) and chloride (Cl) ranged from 802-1452; 9.6-710; 396-6544; 123-654; 1-3.3 and 6368.23-31831.19 mg/l respectively. Standards for these ions except F and Cl are not defined by Pak-EPA. F is within permissible limit while Cl values is much higher than Pak-EPA. Heavy metal results showed that manganese (Mn) and chromium (Cr) ranged from; 1.12-3.66 and 1.3-1.8, respectively. These were compared with Pak-EPA which showed that chromium and manganese were above the permissible limit. In soil sample the same parameters were assessed and found in very high concentrations. From the present study it is concluded that produced water showed highly contamination of pollutants so it should be treated before releasing into the surrounding environment in order avoid the impacts.

Keywords:

wastewater, Soil, physicochemical Characteristics, Pak-EPA

JEL Classification: Q53

INTRODUCTION

Petroleum hydrocarbons (liquid and gas) and water are present in reservoir rocks. Rocks occurring naturally in sub surface mostly filled with fluids i.e. water, oil, or gas or may be filled with combination of these fluids in their pores. Reservoir pressure reduces due to extraction of oil and gas, water is added or injected into the reservoir water layer to retain the hydraulic pressure and to increase or raise the oil recovery. Furthermore, there can be water breakthrough from outside the reservoir area, and as oil and gas production continues, the time comes when formation water reaches production well, and production of water begins alongside the hydrocarbons (Igunnu and Chen, 2012). This water is commonly known as “connate water” or “formation water”, when reservoir is produced and this formation water is brought to the surface along with other fluids it become “produce water” (Atarah, 2011). It is generally categorized as oil field produced water, natural gas produced water and coal bed methane (CBM) produced water according to the source (Igunnu and Chen, 2012). Different types of wastes are produced in oil and gas industries during exploration of oil and gas, these wastes have different characteristics. Out of these wastes liquid waste represent a notable percentage. Produced water is considered as waste but now industries are considering this water as profitable material. Waste water is whether waste or profitable material its management requires cost and that cost must be kept in each project while designing the project or it can affect the well life. Practices for managing produced water must be environmental friendly. Managing practices depend on the produced water composition and also on location, quality and availability of resources (Arthur et al., 2005). Shifts in the composition of soil microbial populations are due to presence of Cr (VI) and cause detrimental effects on microbial cell metabolism at high concentrations (Huang et al., 2009). Excess of sodicity declines the permeability of soil due to which plants eventually become dry and die. Salt bearing plants species will also rise in number (Veil et al., 2004). Excess of salinity in soil increases toxicity of ions, loss of nutrients like Na, Ca, K, P, Fe, Zn. (Shrivastav et al., 2015). Sodicity or excess of salinity decreases the phosphorus uptake of plants (Bano and Fatima, 2009). Over supply of Na to plants leads to osmotic stress and plant death (Munns, 2002). Salinity inhibits the seed germination, seed growth, enzymatic activities, protein synthesis etc. (Javid et al., 2011). Dakhni oil and gas field (Oil and Gas Development Company Limited) is situated at Attock District, Pakistan. This field is located 135 km south west of Islamabad. It was discovered in February 1983 and came on regular production in December 1989. Attock District owes its name from famous Attock Fort, situated on the left bank of the Indus River. The Attock District was constituted in 1904 by taking Talagang Tehsil from Jhelum District and Pindi Gheb, Fateh Jang and Attock Tehsils from Rawalpindi District. The District lies from 33°00´ to 34°00´ north latitudes and 71°43´ to 72°56´ east longitudes. It is bounded on the north by Swabi and Haripur Districts of Khyber Pakhtunkhwa (KPK), on the east by Rawalpindi, on the south by Chakwal District, on the southwest by Mianwali District, in the west by Kohat District and on the northwest by Nowshera District of KPK.

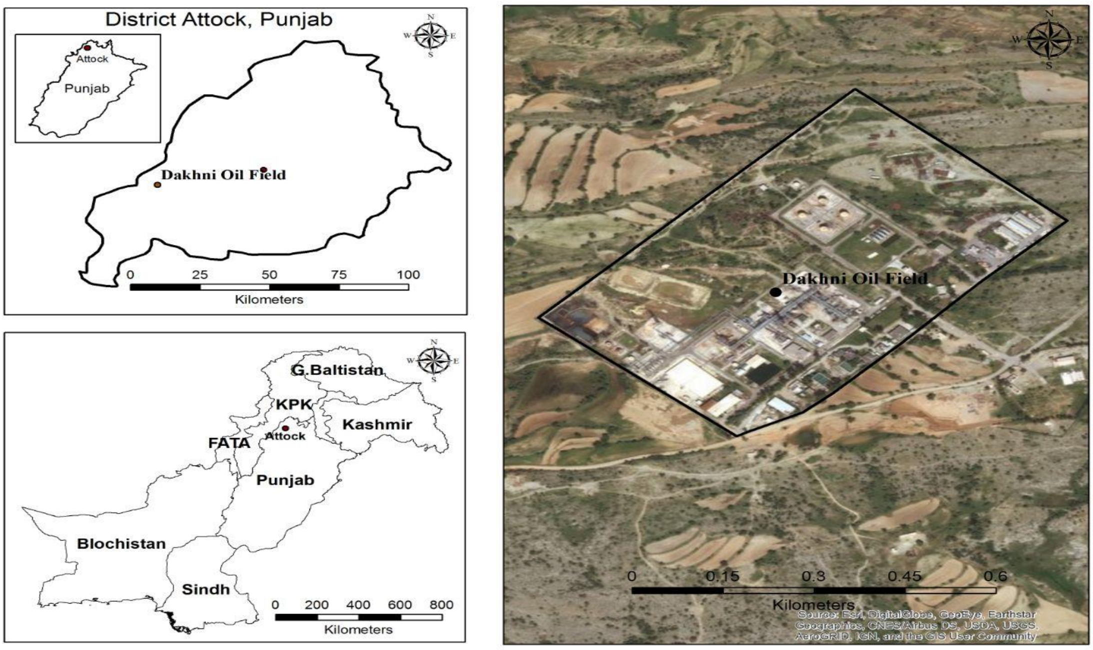

Fig. 1. Map of study area.

Materials and Methodology

Produced water samples were collected and analyzed for physicochemical parameters and heavy metals concentration. Soil samples were collected to analyze the impact of produced water on surrounding soil. For water samples, polythene plastic bottles of 1litre were used to collect the samples. Produced water samples were collected from Inlet, ponds and outlet point. Composite soil samples of 1Kg were collected in self-locking polythene bags from various points at various distances about 0-15 cm depth (Khan et al., 2015). Each bag and bottle was labeled with sample number and sample locations. The physical parameters of produced water were measured on the spot in the field. Other parameters were analysed in the laboratory by using standard methods.

Results and Discussions

Physicochemical and heavy metal concentrations were analyzed in produced water, it was found that pH was ranged between 5.5-7.5, the results of pH of these samples were compared with Pak-EPA as shown in table 1. Other parameters were ranged 21900-82600, 802-1452, 9.6-710, 396-6544, 123-654, 1-3.3, 6368-31841, 1.12-3.66 and 1.3-1.8 mg/l, respectively. These values were compared with maximum permissible limits of Pak EPA, it was found pH and F were with in permissible limit and TDS, Cl, Mn and Cr were found above the limits, for Na, K, Ca and Mg their limits are not defined by Pak EPA. pH has profound effects on water quality affecting the solubility of metals, alkalinity and hardness of water. TDS refers to total dissolved materials present in the water. TDS is measured in parts per million or mg/L. Discharge of water with a high TDS level would have harmful impact on aquatic life, render the receiving water unfit for drinking purposes, reduce crop production if used for irrigation etc. Highest TDS concentration was observed at pond A (out-let). High variation in TDS values and its presence in water more than the permissible limits of water make it harmful for environment. Its increased amount in water makes it acidic, salty, and brackish. TDS increase in water also favours the cations and anions, as TDS values have a positive relation with the major ions (Shakirullah et al., 2005). The primary problem posed by high sodium is a rapid decline in soil structure. Potassium is necessary for living organism functioning hence found in all human and animal tissues particularly in plants cells. Potassium is one of the essential macro minerals for plant survival. Magnesium is an essential element for humans and other animals. Adverse effects can result from both deficiency and overexposure. Water in which magnesium is in high concentrations can have a laxative effect (Sengupta, 2013). "When fluoride exists in these natural elements [soil, water and air], every living organism is affected" (Miller, 2008). Fluoride has no biochemical function and is extremely toxic at large concentrations in plants, animals, humans and our environment.

Table,1. Physicochemical characterises of produced water of the study area

Sample location	pH	Concentration (mg/L)								
		TDS	**Na**	**K**	**Ca**	**Mg**	**F**	**Cl**	**Mn**	**Cr**
Inlet	7.2	82600	1131	710	3345	260	2.9	31841.19	1.91	1.3
pond A (In-let)	6	47750	1452	645	6210	543	3.3	17689.55	2.66	1.7
pond A (Out-let)	7.5	21900	1114	127.3	6544	654	1.2	12028.89	3.66	1.8
pond B (In-let)	6.2	26200	825	178.2	399	431	1.2	7075.82	1.19	1.5
pond B	5.5	26300	802	165.1	396	234	1	6368.23	1.12	1.4
pond B (Out-let)	6.3	28500	882	9.6	798	123	1.3	6368.23	1.4	1.5
Pak-EPA	6_10	3500	ND	ND	ND	ND	20	1000	1.5	1

Cl is a naturally occurring element; Cl can have impacts on the environment when it escapes from industrial settings where it is used in large quantities. If an excess amount of chloride is released by accident into a lake or stream, it may harm aquatic plants and animals until it is diluted to a harmless level. Chloride is categorized as a pollutant for many reasons. In addition, as chloride filters down to the water table, it can stress plant respiration and change the quality of our drinking water (Asche, 2013). Mn is one of the most abundant metals in soils. Mn can cause both toxicity and deficiency symptoms in plants. When the pH of the soil is low manganese deficiencies are more common. Highly toxic concentrations of Mn in soils can cause swelling of cell walls and brown spots on leaves. Cr often accumulates in aquatic life, adding also to the danger eating fish that may have been exposed to high levels of Cr. Cr toxicity effects on plant growth and development include variations in the development process and in the growth of roots, stems and leaves, which may affect production. Cr toxicity effects on plant physiological processes *i.e.* Photosynthesis, water relations and mineral nutrition (Shanker et al., 2005).

Composite soil samples from produced water ponds surrounding area were collected and analyzed in order to evaluate the concentration of physicochemical parameters, and heavy metals content in the soil samples, which were collected from different points at various distances in the field. pH values were ranged 5.4 to 6.1 and their average values were noticed 5.6. Ions and heavy metals were analyzed it was found that Na, K, Ca, Mg and Cl were ranged 130-2926, 13.5-132, 2562-4640, 14-231 3686-5672, 5.19-25 and 1.02- 1.45 mg/l, respectively. There is no permissible limits are mentioned in Pak EPA for soil. Soil pH is evaluated by the concentration of hydrogen ions (H^+). It is affected by both acid and base forming cations in the soil (Cauley et al., 2017). The soil pH also affects the plant growth by its effect on activity of beneficial microorganisms Bacteria that decay soil organic matter are slowed down in strong acid soils. Excessive use of fertilizer will also cause surplus salt in the soil. The primary problem posed by high sodium is a rapid decline in soil structure. The primary physical processes associated with high sodium concentrations are soil dispersion and clay platelet and aggregate swelling. Growth and repair within plant tissues ceases as a result **(**Nikos et al., 2003). K plays vital part in photosynthesis, food formation process of plants and also in transportation and storage of food. K is required in relatively large quantities for the growing plant. The symptoms of K deficiency are: limited growth, reduced flowering, lower production and lower quality (Cauley et al., 2011). The most common symptom of plant K deficiency is yellowing of older plant leaves along the edges and/or between the veins. Leaf tissue may also die, necrosis may occur between the veins. Legumes will also show some symptoms of K deficiency (Cauley et al., 2011). The significance of Ca in the soil is the reduction of soil compaction, improved water infiltration, and help to provide a healthier environment for the production of beneficial bacteria**.** Chloride is known to exist more in more than 130 organic compounds in plants. Most soils contain sufficient levels of chlorine. Most soils contain adequate amounts of chloride for plant nutrition. Symptoms of chloride deficiency are Drooping due to a restricted and heavy branched root system, often with short tips, and spots on leaves and chlorosis. Deficiency of Chloride ultimately affects plant growth (Cauley et al., 2011).Toxicity symptoms of chloride are same as toxicity symptoms due to excessive salts. The leaf boundaries are burned Leaf size is reduced and become thickened and hinder the growth of plant. Chloride is categorized as a pollutant for many reasons. Chloride is necessary for water habitats to thrive, yet high levels of chloride can have negative effects on an ecosystem. Chloride may impact freshwater organisms and plants by altering reproduction rates, increasing species mortality, and changing the characteristics of the entire local ecosystem. In addition, as chloride filters down to the water table, it can stress plant respiration and change the quality of our drinking water (Asche, 2013). Manganese can cause both toxicity and deficiency symptoms in plants. Cr is one of the heavy metals whose concentration is increasing rapidly due to growth of industries (Wyszkowska, 2002). Cr toxicity in soil effects the plant growth and development include variations in the development process and in the growth of roots, stems and leaves, which may affect production. Cr toxicity effects on plant physiological processes *i.e.* Photosynthesis, water relations and mineral nutrition. (Shankar et al., 2005).

Table,2. Physicochemical characterises of soil of the study area

Distance (m)	pH	Concentration (mg/Kg)						
		Na	K	Ca	Mg	Cl	Mn	Cr
30	6	2736	132	4640	188	5672	22.03	1.4
60	6.1	2926	76	4310	122	5672	25	1.34
90	5.5	1942	58.4	4218	231	5104.8	17.5	1.04
120	5.5	2050	56	3616	51	5672	5.92	1.4
150	5.4	1516	76	3176	163	5672	5.19	1.32
180	5.4	650	20	2562	14	4821.2	6.8	1.02
210	5.4	938	13.5	3660	76	5672	10.31	1.28
240	5.6	130	18	3410	22	3686.8	9.6	1.45

Conclusion

The study was conducted to analyse the physio-chemical parameters of produced water of Dakni oil field, Attock, Punjab, Pakistan and their impacts on surrounding soils. The results of physical parameters of produced water including pH and TDS indicate that pH of produced water lies within the defined limits and TDS is much higher than the permissible limits defined by Pak-EPA. Results of ion analysis in produced water samples indicate that Cl values are much higher than the limits defined by Pak-EPA. Heavy metal results showed that Mn and Cr were above the permissible limit. Heavy metals and ions were assessed in the surrounding soil of ponds area which showed the high concentration of Cl and heavy metals. Heavy metals that are above the permissible limit in produced water was also had high concentration in soil. It is also observed that concentration of pollutants decreases with the increasing distance from the ponds. The study concluded that untreated produced water that is discharged into surrounding area have detrimental effect on soil quality, agriculture and human health of the area and also pollute the ground water when percolates into the ground. Produced water is discharged into the surrounding area without any treatment. Environmental Protection Agency of Punjab should have regular monitoring system to check the illegal discharge of produced water into the natural streams and soil and it should be treated physically, chemically, biologically and mechanically properly before disposing off into the surrounding environment.

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