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Physicochemical Properties of Produced Water in Bangladesh

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Abstract - *Produced water is imprisoned in underground formations that is brought to the surface along with petroleum products. It is by far the major byproduct or waste stream associated with oil and gas production. Produced water management has been an issue of concern for oil and gas producers as it is one of the major factors that cause abandonment of the producing well. There are 28 discovered gas field in Bangladesh out of them 22 are at operating condition, producing nearly 2350 MMSCFD gas and 7284 bbl condensate and 23,500 bbl equals 3736500 litter water per day. We tested the produced water sample collected from different gas field in Bangladesh at BASF Bangladesh Ltd. construction chemical Lab. The lab test result showing that the Dissolved oil (oily odor), PH (5.58-7.63), EC (10893-13200 µs/cm-), TS (12230-14228 ppm), TDS (11540-13405 ppm), TSS (671-823 ppm) Na+ (1620-3525.43ppm), Cl- (1395-3423 ppm), HCO3- (258.15-3356.83 ppm), Turbidity (69-78 NTU), COD (730- mg/l), Ca2+ (20.71-252.4 ppm), Fe2+ (4.08-85.3), Fe3+ (9.94-20.36 ppm) and other parameters of produced water are much higher than the acceptable limit defined by Environment and Forest Ministry of Bangladesh.*

Key Words: Oil and gas, Produced water, Properties, Bangladesh.

1.INTRODUCTION

The role of petroleum products (oil and gas) in present civilization is noteworthy but most production movements, oil and gas production process generate huge amount of liquid waste known as Produced water (PW)[1]. Produced water is the water trapped in underground formations that is brought to the surface during oil and gas exploration and production [2]. In traditional oil and gas wells, produced water is brought to the surface along with oil or gas. Because the water has been in contact with the hydrocarbon-bearing formation for a very long time, it has some of the chemical characteristics of the formation and the hydrocarbon itself. Produced water may include water from the reservoir, water injected into the formation, and any chemicals added during the drilling, production, and treatment processes. Produced water can also be called "brine", "saltwater", or "formation water."[3, 4].

2. PRODUCED WATER PRODUCTION SYSTEM IN BANGLADESH

There are 28 discovered gas field in Bangladesh out of them 22 are at operating condition, producing nearly 2350 MMSCFD gas and 7284 bbl condensate and huge amount of water daily[5]. The gas water ratio in SGFL is 1:20.91[6] (for 1MMscf gas production, produced water 20.91 bbl.) which is 1:1.78 in BGFCL [7]. If the gas production and water production ratio consider as 1:10, total amount of water production nearly 23,500 bbl equals 3736500 litter per day. The water production from Bangladeshi gas fields are given in table 1.

Table 1: Water production from Bangladeshi gas fields [5-7].

Company	Field	Gas Production (MMscf)	Water production (bbl)	GWR	Avg. GWR
SGFL	HGF	7.6007	441.010	58.02	20.91
	KGF	4.0821	208.790	51.15	
	MSTE	25.2380	4.529	0.18	
	RGF	44.2970	632.91	14.29	
	BGF	7.6609	573.725	74.89	
BGFCL	Titas	369.397	758	2.05	1.78
	Habiganj	164.058	161	0.98	
	Bakhrabad	35.127	67	1.91	
	Narsingdi	26.899	28	1.04	
	Meghna	7.208	62.60	8.68	
BAPEX	-	134.1	-	-	-
IOC's	-	1502	-	-	-

3. METHODOLOGY

Produced water is the main wastage in gas filed during gas production. Sample of produced water were collected from three different gas fields in Bangladesh. The common parameters such as Physical Properties (Temperature, Density), pH, Turbidity, EC, Turbidity, Total solids (TS), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Iron (Fe^{2+} & Fe^{3+}), Bicarbonate (HCO_3-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Chloride (Cl^{-}), Chemical Oxygen Demand (COD) , Biochemical Oxygen Demand (BOD) of samples water were estimated from lab test at QC Lab,

BASF Bangladesh Ltd. Satandard methods were applied to measure the water parameters**.** The testing methods showing in table 2.

Table 2: PW parameters testing methods

Elements/ Parameters	Methods/Device
pH	HANNA HI98107 pocket pH mete
EC	HANNA HI99301
Turbidity	Portable turbidimeter (HACH-2100Q)
TS, TDS, TSS	HANNA -HI99301 meter
Iron (Fe^{2+} & Fe^{3+})	UV-visible spectrophotometer
Bicarbonate (HCO_3^-)	Soda reagent method
Calcium (Ca^{2+})	Complex metric titration method
Magnesium (Mg^{2+})	Volumetric method
Sodium (Na^+)	Flame photometric method
Chloride (Cl^-)	Mohr method
Chemical Oxygen Demand (COD)	MD 200 COD vario instrument

4. RESULT AND DISCUSSION

4.1 Physical Properties

Physical parameters state those characteristics of water that respond to the senses of eyesight, touch, taste or odor. The samples water was oily odor and its density is higher than normal water. The PW density were 1020, 1022, 1021 kg/m3 for different gas field where worldwide gas field PW density is between 1014 to 1140 kg/m3. The lab room temperature was 77O F or 25O C during all the tests performed.

4.2 Hydrogen Ion Concentration (pH)

PH is a quantity of the hydrogen ion concentration in water and specifies whether the water is acidic or alkaline in nature. The value of pH ranges from o to 14 where value 7 indicate neither acidic nor alkaline. The values within 7 to 0 are gradually acid and within 7 to 14 is progressively alkaline water. PH is also an indicator of the presence of biological life as most of them succeed in a quite narrow and critical PH range [8, 9] The PH value of water sample Field I, Field II and Field III are 7.44, 7.63 and 5.58 respectively where worldwide gas producing well water PH is 3.1-7.0. [1, 10].

4.3 Electric Conductivity (EC)

Conductivity designates the existence of ions within the water. Immersing a conductance cell in water samples the EC was measured and recorded from the digital display of the EC meter. The EC value of the sample water are 11230 µs/cm ,13200 µs/cm and 10893 µs/cm for field I, field II and field III respectively which is within the global gas filed PW limit. The EC of water samples shown in figure 1.

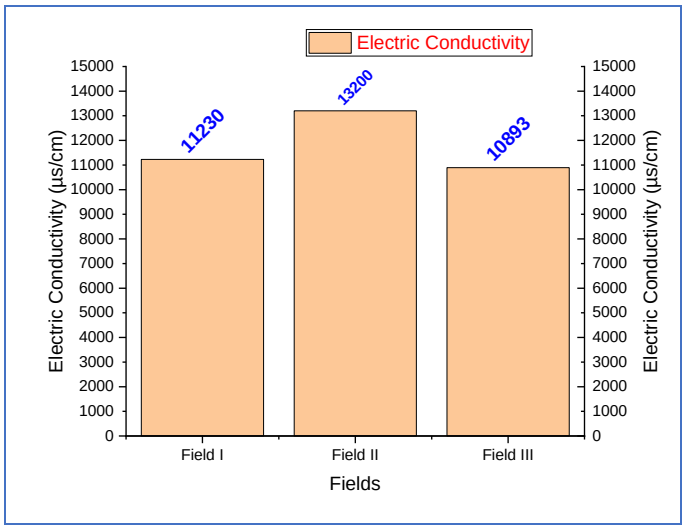

Figure 1: Electric Conductivity (EC) of Bangladeshi gas field produced water.

4.4 Turbidity

Turbidity is a degree of the extent to which light is either absorbed or scattered by adjourned elements in the water. Aabsorption and scattering are influenced by both size and surface characteristics of the suspended material but turbidity is not a straight numerical quantity of suspended solids. The turbidity of the PW samples are 70 NTU, 78 NTU and 69 NTU for field I, field II and field III respectively.

4.5 Total solids (TS), Total Dissolved Solids (TDS) and Total Suspended Solids (SS)

The total solids (TS) in water contain of inorganic salts and dissolved compounds. In normal waters, salts are chemical compounds comprised of anions such as HCO3-, Cl, sulphates, and nitrates (primarily in ground water), and cations such as K, Mg, Ca, and Na. Total Dissolved Solids (often abbreviated TDS) is a amount of the combined content of all inorganic and organic substances contained in a liquid in: molecular, ionized or micro-granular suspended form [8, 9]. Suspended materials contain of particles greater than molecular size that are supported by buoyant and viscous forces within the substance. The value of TS of water sample are 13214 ppm, 14228 ppm and 12230 ppm and TDS value are 12543 ppm, 13405 ppm and 11540 ppm for field I, II and III respectively. The value of TS, TDS and TSS for various PW sample shown in **figure 2.**

4.6 Iron (Fe2+ & Fe3+)

Ingestion of excessive amounts of iron results in the inhibition of activity of many enzymes. Water becomes deficient in oxygen by ferric iron [8]. Such poisoning of steams is reckoned to be one of the main causes of fish kill. Water containing less than 2 ppm Fe cause staining of clothes and imparts a bitter taste [8]. The iron concentration in the sample water are 10.32 ppm and 20.36 ppm as Ferrous (Fe2+) and Ferric (Fe3+) respectively in water

sample for gas field I, 4.08 ppm and 12.30 ppm for field II and 85.3 ppm and 9.94 for water sample III. The Iron concentration of water samples are shown in figure 3.

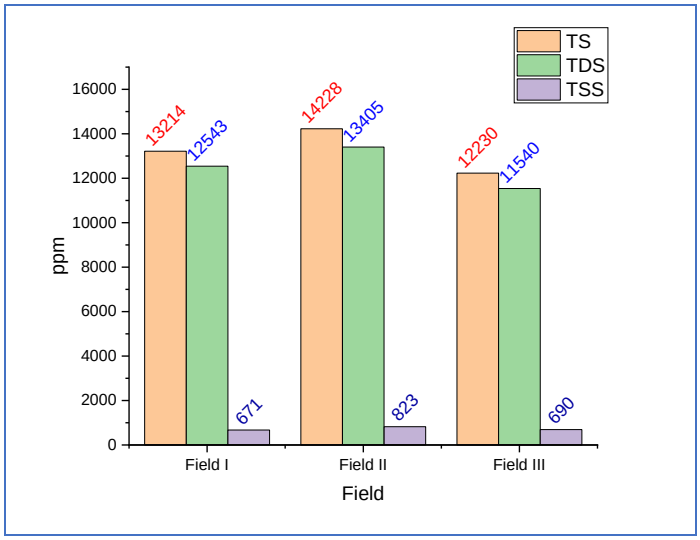

Figure 2: TS, TDS and TSS of sample water of different gas field in Bangladesh.

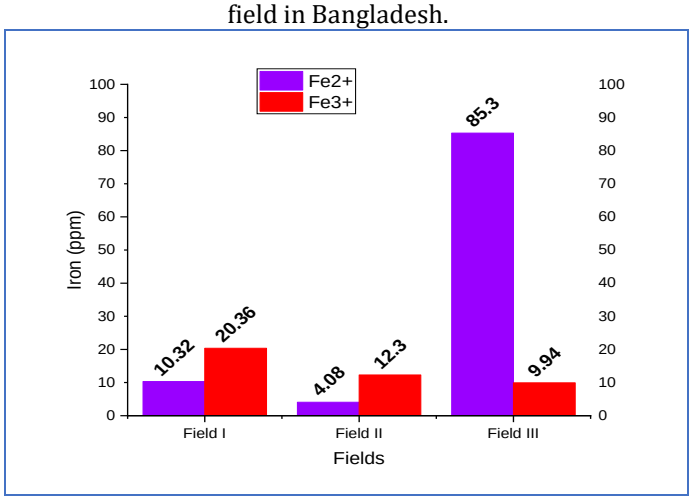

Figure 3: Iron concentration of the sample water.

4.7 Bicarbonate (HCO3-)

HCO_3^-, the bicarbonate ion, is the main alkaline factor in almost all water. Alkalinity serves as a buffer, neutralizing acids. Alkalinity is a measure of the capacity of water or any solution to neutralize or "buffer" acids. This measure of acid neutralizing capacity is important in figuring out how "buffered" the water is against sudden changes in pH [Aziz M.A. 1975]. The most important compounds in water that determine alkalinity include the carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) ions. The concentration of Bicarbonate (HCO_3^-) in the samples water are 3356.83 ppm, 3226.90 ppm and 258.15 ppm for field I, II and III respectively.

4.8 Calcium (Ca2+)

Calcium is normally present in natural water in dissociated form, as bivalent ions and is mostly responsible for causing hardness in water. Presence of calcium in water is excess of about 100 ppm decrease the cleaning and lathering properties of soap. Higher calcium concentration than maximum acceptable limit of some samples may be due to the presence of plagioclase feldspar (Anorthite) in the sediment. The concentration of calcium ion in samples water are 20.71 ppm, 24.01 ppm and 252.4 ppm which are within the worldwide gas field produced water limit (9400 ppm - 51,300 ppm) shown in figure 4.

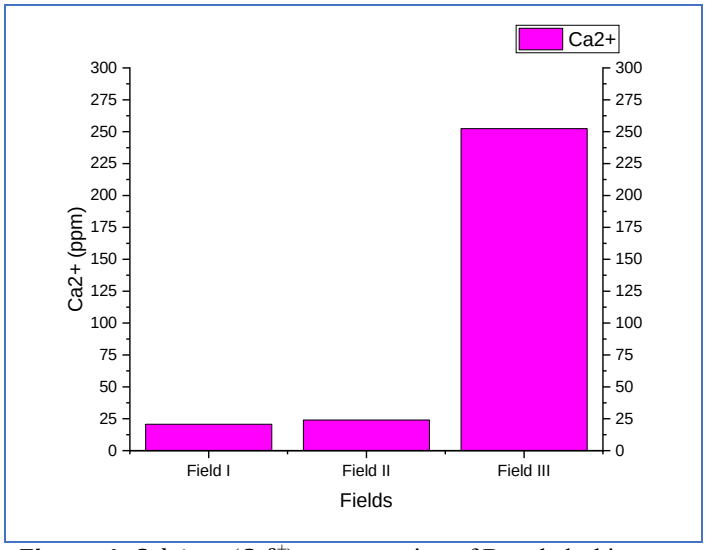

Figure 4: Calcium (Ca^{2+}) concentration of Bangladeshi gas filed produced water.

4.9 Magnesium (Mg2+)

Magnesium is common basic of natural water. Hardness of water depends on the concertation of Magnesium in water which breaks down when heated and form scale in boilers or heating equipment. The magnesium concentration may vary from zero to 100 ppm, depending on the source and treatment of the water [8]. The volumetric method applied for determining the concentration magnesium of the sample water. The magnesium concentration in sample water is 26.31 ppm, 25.54 ppm and 54.3 ppm for field sample I, II, III respectively. The Magnesium concentration of Bangladeshi gas field produced water shown in **figure 5**.

4.10 Sodium (Na^+) Chloride (Cl^-)

Sodium and chloride is widely distributed in nature, generally in the form of sodium chloride (NaCl) but chloride found as potassium chloride (KCl) and calcium chloride (CaCl2) also [8, 9] . Sodium and chloride occur naturally in water because of erosion or salt water intrusion (when salt water from the ocean seeps into underground water supplies). Sodium may reach both ground and surface water

supplies because of residential, commercial and industrial activity, such as road salting. Produced water is mainly brain where concentration of sodium and chloride is much higher than the sea water. The concentration of Na^+ and Cl^- in samples water are shown figure 6.

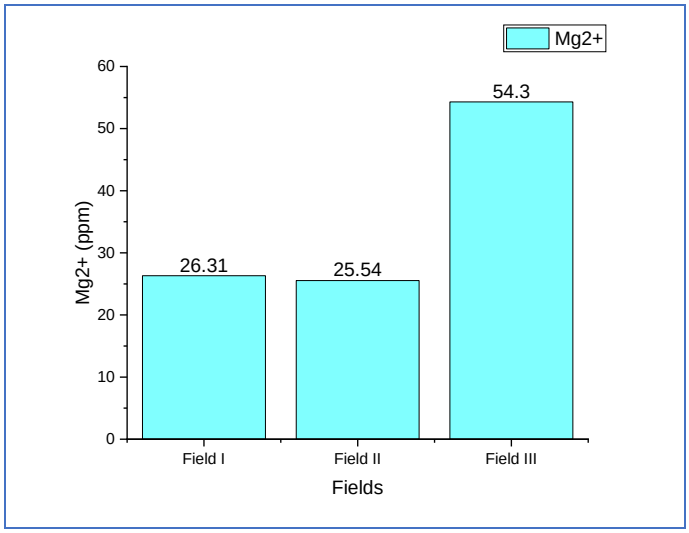

Figure 5: Concentration of Magnesium in Bangladeshi gas field produced water.

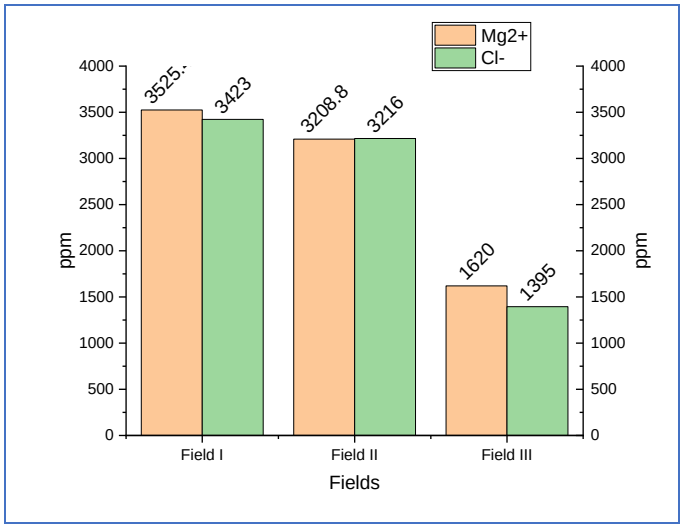

Figure 6: Sodium and Chloride concentration of the sample water.

4.11 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand or BOD is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period [1]. It is most commonly expressed in milligrams of oxygen consumed per liter of sample during 5 days (BOD5) of incubation at 20°C and is often used as a robust surrogate of the degree of organic pollution of water. As the sample water is saline water, concentration of Na and Cl- and other salt are higher than the acceptable limit no microorganisms can grow in the water. So, the value of BOD is not measurable.

4.12 Biochemical Oxygen Demand (BOD)

Chemical Oxygen Demand or COD is the amount of the oxygen essential to oxidize soluble and particulate organic matter in water. Chemical oxygen demand is an important water quality parameter because, it provides an index to assess the effect discharged wastewater will have on the receiving environment. The COD in sample water are 730 mg/L, 670 mg/L, 771 mg/L for field I, II and III shown in **figure 7.**

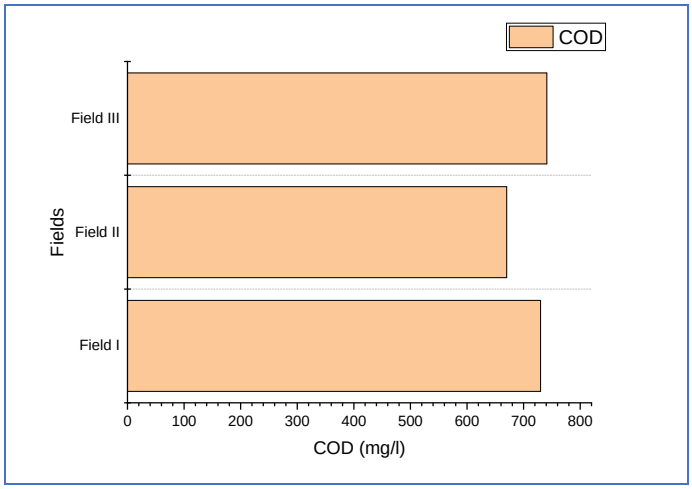

Figure 7: COD of the sample water

The result from the laboratory analysis presented above are summarized in table 3.

5. CONCLUSIONS

The volume of produced water produced from all gas fields in Bangladesh is not small. The all parameters are higher than the acceptable discharge limit define by Environment and Forest Ministry of Bangladesh. Most of the local company use skiming pit to manage the produced water which may affect nearby ground water and environment. The IOC's use injection well to discharge the water which also affect the lower formation water. Bangladesh government should take necessary steps to the mange produced water as water resource.

Table 3: Physiochemical properties of produced water in Bangladesh.

Parameters	**Field I**	**Field II**	**Field III**	Worldwide gas field produced water
Physical Appearance	oily odor	Oily odor	Oily odor	Oily odor
Temperature (Lab temperature)	77^0 F or 25^0 C	77^0 F or 25^0 C	77^0 F or 25^0 C	-
P^H	7.44	7.63	5.58	3.1-7.0
Density (kg/m^3)	1020	1022	1021	1014–1140
Turbidity NTU	70	78	69	-
TS (ppm)	13214	14228	12230	-
TDS (ppm)	12543	13405	11540	2600-360,000
TSS (ppm)	671	823	690	8-5485
Conductivity (µs/cm)	11230	13200	10893	4200- 586,000
Chloride (Cl^-) (ppm)	3423	3216	1395	1400- 190,000
Bicarbonate HCO_3^-(ppm)	3356.83	3226.90	258.15	0-285
Calcium Ca^{2+} (ppm)	20.71	24.01	252.4	9400- 51,300
Magnesium Mg^{2+} (ppm)	26.31	25.54	54.3	0.9- 4300
Ferrous Fe^{2+}(ppm)	10.32	4.08	85.3	39-1100
Ferric Fe^{3+} (ppm)	20.36	12.30	9.94	
Sodium Na^+ (ppm)	3525.43	3208.80	1620	520-120,000
BOD_5 mg/L	Not measurable	Not measurable	Not measurable	75-2870
COD mg/L	730	670	741	2600-120,000

ABBREVIATIONS

PW: Produced Water; SGFL: Sylhet Gas Field Ltd.; BGFCL: Bangladesh Gas Field Company Ltd.; BAPEX: Bangladesh Petroleum Exploration and Production Company Limited; IOC: International oil Company; MMSCFD: Million Standard Cubic Feet Per Day; IOC: International Oil Company; TS: Total solids; TDS: The Total Dissolved Solids; WGR: Water gas ratio; ppm—Parts per Million; NTU—Nephelometric Turbidity Unit;

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