International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Correlation Analysis of Formation Water of Upper Assam Basin for a Greener Ecosystem

Konwar D.[a], Gogoi SB[a,*], Barman J[a] , Gogoi MP[a]
[a] Department of Petroleum Technology, Dibrugarh University

***Abstract**: Formation Water (FW) is a complex mixture of organic and inorganic compounds and the largest volume of by-product generated during oil and gas recovery operations. It contains substantial quantity of contaminants and other suspended particles and therefore, it cannot be disposed off directly or cannot be injected to the sub-surface for secondary recovery purposes keeping in view of the environmental concerns. Therefore, evaluation of FW characteristics is very important and essential for both environmental and reservoir management. This paper examines the characterisation of eight (8) FW samples produced from oilfields of Upper Assam Basin. It includes the analysis of organics, inorganics, Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO), hardness, oil and grease (O&G), pH, turbidity, conductivity (EC), Total Dissolved Solids (TDS), Salinity (Sal). The characterisation of the samples of formation water is analysed and on the basis of that its values are compared with World Health Organization (WHO) specification to meet the government discharge regulations of waste water for a greener ecosystem. A correlation and regression study is done to quantify the association between the parameters and it showed a linear relationship among different pairs of parameters. The results proved to be a useful mean for rapid monitoring of water quality with the help of systematic calculations of correlation coefficient between water parameters and regression analysis.*

Keywords: Formation water, characterization, contaminants, discharge regulation, correlation analysis, regression analysis.

1. Introduction

FW is a term used in the oil industry to describe water that is produced when oil and gas are extracted from the ground. Oil and gas reservoirs have a natural water layer (FW) that lies under the hydrocarbons. Oil reservoirs frequently contain large volumes of water, while gas reservoirs tend to have smaller quantities [7]. Petroleum is a major source of energy and revenue for many countries today, and its production has been described as one of the most important industrial activities in the twenty-first century [8]. Despite its significance, petroleum is produced with large volumes of waste, with wastewater accounting for more than 80% of liquid waste [9] and as high as 95% in ageing oilfields [10]. As more and more world major oilfields mature, more water begins to be produced from oil producers because of aquifer encroachment and/or water injection [11]. Currently, it has been well known that the oil industry has to handle more produced water (PW) than oil which makes the oil industry looks more like a "water industry" [12]. Moreover, PW represents approximately 98 % of the total volume of production waste generated by the oil and gas industry [13].

The North-East India oil field PWs are the by-products generated during various operations in the hydrocarbon exploration industries are major sources of pollution in the area. These pollutants find their way and traverse to various environmental receptors causing potential danger of polluting the same. The water bodies, both surface and underground are more susceptible to such pollution in oil fields. Management of oil field PW is a key issue for the oil and gas producers because of its large volume of generation and high handling cost [5]. PW characteristics and volume can vary throughout the lifetime of a well [14].

PW is usually very salty and may contain suspended and dissolved solids, residual hydrocarbons, numerous organic species, heavy metals, naturally occurring radioactive and chemicals used in hydrocarbon extraction [15, 16, 17].

It is well known that no straight forward reasons can be advanced for the deterioration of water quality, as it is dependent on several water quality parameters. There exists strong correlations among different parameters

and a combined effect of their inter-relatedness indicates the water quality. The developed regression equations for the parameters having significant correlation coefficients can be successfully used to estimate the concentration of other constituents. A systematic study of correlation and regression coefficients of the water quality parameters not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water and provide necessary cue for implementation of rapid water quality management programmed[6]. In this work the physicochemical characteristics of FW are identified and compare those data with WHO specifications. A correlation and regression study is done to quantify the association between the parameters and it showed a linear relationship among different pairs of parameters. The results proved to be a useful mean for rapid monitoring of water quality with the help of systematic calculations of correlation coefficient between water parameters and regression analysis.

2. Experiments:

2.1 Materials:

The following materials are used for the experimental work:

Table 1: Materials used in the experiments

SN	Materials	Specification	Source
1	FW-1		
2	FW–4		
3	FW-7		
4	FW-8	Barial formation	OIL E & P
5	FW-3		
6	FW-5		
7	FW-7		
8	FW-8		
9	EDTA (Ethylene Diamine Tetra Acetic Acid)	0.01M	
10	Erichrome black indicator	0.5g in 100ml	RFCL Limited
11	Sodium Chloride (NaCl)	M.W. 58.44 g/mol	
12	Hydrochloric Acid (HCl)	M.W. 36.46 g/mol, Sp. Gr. at 25^0C is about 1.18	
13	Phenolphthalein	pH range 8.2-10 (colourless to pink)	
14	pH buffer	pH 10	WTW
15	Potassium Chloride (KCl)	M.W. 74.56 g/mol	Avantor Performance Materials India Limited
14			RFCL Limited
15	Calcium Carbonate ($CaCO_3$)	M.W. 100.09 g/mol	Merck Specialities Pvt. Ltd.
15	Lithium Carbonate (Li_2CO_3)	M.W. 73.89 g/mol	Spectrochem Pt. Ltd. Mumbai (India)
17	Petroleum Ether	Wt. per ml at 20^0C, 0.630-0.645g	Fisher Scientific
19	Methyl Orange	-	Human Diagnostics & Surgichem

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

2.1 Instruments:

The following instruments were used for the experimental work

Table 2: Equipments used in the experiments

SN	Parameters	Instruments	Chemicals used
1.	pH		
2.	Sal		
3.	EC	**Make**-Systronics	-
4.	TDS	**Model**-Water Analyser 371	
5.	Turbidity		
6.	DO		
7.	BOD	**Make**- VELP Scientifica **Model**- FOC	Potassium Hydroxide (KOH)
8.	Sodium (Na)	**Make**-Systronics	NaCl
9.	Potassium (K)	**Model**-Flame Photometer128	KCl
10.	Calcium (Ca)	Compressor 126	$CaCO_3$
11.	Lithium (Li)		Li_2CO_3
12.	Manganese (Mn)	**Make**-Perkin Elmer	
13.	Iron (Fe)	**Model**-Atomic Absorption Spectrophotometer Analyst 200	-
14.	Chromium (Cr)		
15.	Copper (Cu)		

2.2 Experimental

2.3.1 Physical, Chemical and Biological characterization of FW

2.3.1.1 Water Analyzer

The physical properties of formation water like pH, Sal, EC, TDS, Turbidity and DO are determined by Water Analyzer.

2.3.1.2 Titration methods

Alkalinity: 50 ml sample water + methyl orange titrated with 0.05 N HCl = T

HCO_3 in gm/L = $\frac{T \times 0.05 \times 50 \times 1000}{sample}$

Total Alkalinity = $HCO_3 \times 0.82$

Total hardness: 50 ml sample water + buffer solution 10 (3-4 drops) + Erichrome black indicator, then titrated with EDTA 0.01 M or 0.02N. A change to ink colour was observed after titration.

Total hardness = $\frac{EDTA \times 1000}{sample}$ mg/L

2.3.1.3 O & G

20 ml sample water +20 ml petroleum ether in separating funnel was mixed and shaken for a half an hour. Appearance of two layers was observed where the lower layer was separated out in the beaker then dried in the oven and weighed = y, x= wt of the empty beaker.

$$\text{O \& G} = \frac{(y-x)\times 10^6}{sample}\ \text{mg/l}$$

2.3.1.4 Flame Photometer

Flame Photometer instrument is used to determine Na, K, Li and Ca present in the FW.

Preparation of stock standard solution

1. Na: A standard solution of 1000 ppm is prepared by dissolving 2.5416g NaCl in one litre of distilled water.
2. K: A standard solution of 1000 ppm is prepared by dissolving 1.9070 g KCl or 2.5869 g KNO_3 in one litre of distilled water.
3. Ca: A standard solution of 1000 ppm is prepared by dissolving 2.497 g $CaCO_3$ in approx 300 ml glass distilled water and adding 10 ml conc. HCl in one litre of distilled water.
4. Li: A standard solution of 2000 ppm is prepared by dissolving 4.945 g Li_2CO_3 in approx 300 ml glass distilled water and adding 15 ml conc. HCl in one litre of distilled water.

2.3.1.5 AAS

Determination of Fe, Cu, Mn and Cr in FW was conducted in the instrument Atomic Absorption Spectrophotometer (AAS). Prior to the determination of the amount present, the AAS equipment was calibrated and analyzed using blank solution of 2% Nitric acid (HNO_3) solution and standard solutions of 1ppm, 2ppm, 3ppm and 4ppm of Fe solution for Fe test. Similarly for Cr, Mn and Cu 1ppm, 2ppm, 3ppm and 4ppm of Cr, Mn and Cu standards samples were made respectively. After calibration samples were aspirated, the results were obtained.

2.3.2 Correlation coefficient and Linear Regression

Correlation is the relationship and association between variables. The two terms (i.e “relationships” and “association”) mentioned above “are often used interchangeably; and they refer to the extent to which one variable changes (in quantity or quality) in response to change in another variable”.[20]

Let X and Y are the two variables, and then the correlation coefficient [PEARSON] (r) between the variable X and Y is given by

$$r = \frac{N\sum xy - (\sum x)(\sum y)}{\sqrt{[N\sum x^2 - (\sum x)^2][N\sum y^2 - (\sum y)^2}}$$

Where,

N = number of pairs of parameters

$\sum xy$ = sum of the product of the paired parameters

$\sum x$ = sum of x parameters

$\sum y$ = sum of y parameters

$\sum x^2$ = sum of squared x parameters

$\sum y^2$ = sum of squared y parameters

The quantity r, measures the strength and the direction of a linear relationship between two variables. The linear correlation coefficient is sometimes referred to as the Pearson product moment correlation coefficient in honour of its developer Karl Pearson.[22]

The value of ‘r’ can be expressed as values between +1 and -1. A coefficient of +1 indicates a perfect positive correlation: A change in the value of one variable will predict a change in the same direction in the second variable. A coefficient of -1 indicates a perfect negative correlation: A change in the value of one variable predicts a change in the opposite direction in the second variable. Lesser degrees of correlation are expressed as non-zero decimals. A coefficient of zero indicates there is no discernable relationship between fluctuations of the variables.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

If the values of correlation coefficient 'r' between two variables X and Y are fairly large, it implies that these two variables are highly correlated. In such cases it is fissile to try linear relation in the form-

$$Y=a+bX \quad \text{.....Equation (i)}$$

The value of empirical parameters 'a' and 'b' are calculated with the help of the following equation:

$$a = \frac{\sum y \sum x^2 - \sum x \sum x}{n\sum x^2 - (\sum x)^2} \quad \text{.....Equation (ii)}$$

$$b = \frac{n(\sum x\ ) - \sum x \sum y}{n(\sum x^2) - (\sum x)^2} \quad \text{.....Equation (iii)}$$

3 Results and Discussions

3.1 Physico bio-chemical characterization of FW

Table 3: Physical, Chemical and Biological characterization of FW

Parameters	FW-1	FW-2	FW-3	FW-4	FW-5	FW-6	FW-7	FW-8
pH	8.1	6.71	7.07	7.46	6.72	7.85	6.7	7.07
EC (mS)	8.98	4.19	1.77	11.6	1.76	18	19.5	7.05
TDS (ppt)	6.47	3.14	1.95	7.95	0.97	10	11.3	3.59
DO (ppm)	3.3	3.3	4.9	2.7	5.3	2.3	5.3	3.1
Sal (ppt)	5.12	3.74	1.96	9.29	1.2	11	11.8	6.11
Turbidity (NTU)	113	82	4.4	8	12	187	34	168
Chloride (Cl) (mg/L)	7.158	0.728	6.43	3.807875	2.535744467	0.896521054	66.59211	
Alkalinity (mg/L)	725.29	675.27	85.034	110.044	140.056	28.7	210.084	560.224
Hardness (mg/L)	68	70	50	48	40	54	42	58
O & G (mg/L)	2000	3500	1333.33	1000	2000	2700	2200	1900

Table 3 shows that the most of the parameters of FW showed values higher than the maximum permissible limits for its disposal. The pH of the eight samples is almost neutral with the exception of FW-1 having an alkaline nature. The high value of EC can be attributed to the fact that FW has ions so the EC is well above pure water which is 0.55mS [2]. FW has dissolved and suspended solids which lead to its high value of TDS. DO is the amount of gaseous oxygen (O_2) present in water. The DO values showed much lesser values than the discharge regulation values which is harmful for the aquatic animals. The saline FW must be treated or it affects the agricultural and aquatic habitat. The high values of turbidity are due to the presence of suspended and dissolved solids in FW. It poses several problems for stream systems. Higher turbidity levels are often associated with higher levels of viruses, parasites and some bacteria because they can sometimes attach themselves to the dirt in the water [18]. Alkalinity of FW is the capacity of FW to neutralize an acid. It showed values higher than the normal values of discharge regulations. Hardness, a physico chemical property of water, is generally a measure of calcium and magnesium ions in water [19]. The high values of hardness are detrimental for human health. O & G in FW is due to the presence of suspended oil particles in the water samples.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Table 4: BOD calculations of FW

Sl. No.	Sample	DO (Day 1) (ppm)	DO (Day 5) (ppm)	BOD (ppm)
1.	FW-1	5	3.3	1.7
2.	FW-2	7.6	3.3	4.3
3.	FW-3	5.6	4.9	0.7
4.	FW-4	5.9	2.7	3.2
5.	FW-5	5.9	5.3	0.6
6.	FW-6	6.1	3.2	2.8
7.	FW-7	5.5	4.7	0.8
8.	FW-8	4.9	2.7	2.2

Table 4 showed the BOD values for the samples. BOD value is obtained by incubating the sample for 5 days at 20^0C.

Table 5: Inorganics determined by AAS and FP

Sl. No.	Parameters (ppm)	FW-1	FW-2	FW-3	FW-4	FW-5	FW-6	FW-7	FW-8
1.	Fe	2.47	1.011	0.024	0.337	0	0	0.89	0.337
2.	Cu	0	0	0	0	0	0	0	0
3.	Cr	0	0	0	0	0	0	0	0
4.	Mn	0.057	0.057	0.046	0.031	0.075	0.046	0.063	0.031
5.	Na	1378	1967	1664	1295	924.6	277	2794	1295
6.	K	195	81	53	275	39.1	69	64	275
7.	Ca	982	379	344	527	911.9	627	422	527
8.	Li	121	21	17	20	499.1	15	17	20

Table 5 showed the inorganics values for the formation water samples which is obtained by analysing in Atomic Absorption Spectrometer and Flame Photometer.

Table-6: Comparison of formation water quality with WHO specification

Parameters	WHO specification	Present study report
pH	6.0 to 9.0	6.7-8.1
Cond. (mS)	0.25-0.75 mS	1.76-19.5 mS
TDS (ppt)	24.59 ppt	0.97-11.3 ppt
DO (ppm)	7 ppm	2.3-5.3 ppm
Salinity (ppt)	200-400 ppt	1.2-11.8 ppt
Turbidity (NTU)	5-10 NTU	4.4-187 NTU
Alkalinity (mg/L)	200 mg/L	28.7-725.29 mg/L
Hardness (mg/L)	300 mg/L	40-70 mg/L
O & G (mg/L)	250 mg/L	1000-3500 mg/L
BOD	30 ppm	0.6-4.3 ppm
Fe	3.0 ppm	0-2.47 ppm
Cu	3.0 ppm	0 ppm
Cr	2.0 ppm	0 ppm
Mn	0.050 ppm	0.031-0.075 ppm
Na	200 ppm	277-2794 ppm
Ca	75 ppm	344-982 ppm

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Table 6 is the comparison tables of the values obtained from the experimental study to the WHO specification which is a standard for safe disposal of water to the environment. EC, Turbidity, Alkalinity, Hardness, O&G, Na and K showed values much higher than the safer limits for its disposal. Whereas DO value showed lower values than the permissible limits which indicates low level of free, non-compound oxygen present in water.

3.2 Correlation analysis of formation water

Table 7 shows the statistical analysis of formation water samples

Table-7: Statistical Analysis of various water samples parameters

Parameters	Max	Min	Range	Mean	SD	SE	%CV
pH	8.1	6.7	1.4	7.21	1.183215957	0.418330013	16.41076
EC (mS)	19.5	1.76	17.74	9.10625	4.211887938	1.489127261	46.25272
TDS (ppt)	11.3	0.97	10.33	5367125	3.214031736	1.136331818	56.67237
DO (ppm)	5.3	2.3	3	3.775	1.732050808	0.612372436	45.88214
Sal (ppt)	11.8	1.2	10.6	6.2775	3.255764119	1.151086443	51.86402
Turbidity (NTU)	187	4.4	182.6	76.05	13.51295675	4.777551674	17.76852
BOD (ppm)	4.3	0.6	3.7	2.0375	1.923538406	0.680073525	94.40679
Alkalinity (mg/L)	725.29	28.7	696.59	316.8378	26.39299149	9.331331631	8.330127
Hardness (mg/L)	70	40	30	53.75	5.477225575	1.936491673	10.19019
Cl (mg/L)	7.158	0.728	6.43	3.807875	2.535744467	0.896521054	66.59211
O & G (mg/L)	3500	1000	2500	2079.166	50	17.67766953	2.40481
Na (ppm)	2794	277	2517	1575.325	50.16971198	17.73767178	3.184721
K (ppm)	275	39.1	235.9	130.1375	15.35903643	5.430239405	11.80216
Ca (ppm)	982	344	638	567.8625	25.25866188	8.93028555	4.448024
Li (ppm)	499.1	15	484.1	91.0125	22.00227261	7.778978082	24.175
Fe (ppm)	2.47	0	2.47	0.5915	1.571623365	0.555652769	265.7013
Cu (ppm)	0	0	0	0	0	0	0
Cr (ppm)	0	0	0	0	0	0	0
Mn (ppm)	0.075	0.026	0.049	0.050125	0.221359436	0.078262379	441.6148

	pH	EC	TDS	DO	Sal.	Turb.	BOD	Alk.	Hard.	Cl.	O&G	Na	K	Ca	Li	Fe	Cu	Cr	Mn
pH	1																		
EC	0.318	1																	
TDS	0.382	0.983	1																
DO	-0.65	-0.27	-0.29	1															
Sal.	0.281	0.973	0.961	-0.36	1														
Turb.	0.485	0.326	0.242	-0.67	0.312	1													
BOD	0.166	0.089	0.121	-0.79	0.210	0.379	1												
Alk.	0.080	-0.25	-0.22	-0.23	-0.25	0.366	0.352	1											
Hard.	0.379	-0.18	-0.12	-0.58	-0.17	0.539	0.629	0.824	1										
Cl.	0.281	0.973	0.961	-0.36	0.999	0.312	0.210	-0.25	-0.17	1									
O&G	-0.18	0.095	0.037	-0.16	0.022	0.464	0.467	0.419	0.500	0.022	1								
Na	-0.56	0.030	0.031	0.079	0.079	-0.19	-0.12	0.397	0.036	0.079	0.016	1							
K	0.400	0.067	0.114	-0.58	0.216	0.236	0.352	0.355	0.283	0.216	-0.44	0.139	1						
Ca	0.476	-0.05	-0.02	0.022	0.027	0.027	-0.26	0.091	-0.01	-0.19	-0.04	-0.56	-0.04	1					
Li	-0.22	-0.44	-0.48	0.479	-0.54	-0.31	-0.45	-0.12	-0.38	-0.54	-0.04	-0.35	-0.31	0.693	1				
Fe	0.407	0.111	0.219	-0.08	0.016	0.079	0.087	0.691	0.583	0.016	0.206	0.187	0.165	0.445	-0.08	1			
Cu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Mn	-0.36	-0.11	-0.11	0.649	-0.29	-0.34	-0.40	-0.08	-0.20	-0.29	0.388	-0.07	-0.75	0.516	0.657	0.29	0	0	1

Table-8: Correlation coefficient between various water quality parameters

***Turb.: Turbidity

***Alk.: Alkalinity

***Hard.: Hardness

The value of r measures the degree of association that exists between two variables, one taken as dependent variable. The greater the value of r, the better is the fit and more useful the regression variables [21]. Correlation is the mutual relationship between two variables. Direct correlation exists when increase or decrease in the value of one parameter is associated with a corresponding increase or decrease in the value of other parameter [6]. In this study, the numerical values of r for the nineteen water quality parameters are tabulated in Table 9.

Positive correlation is obtained between 134 pairs which is 70.52% of the total number and rest of the 56 pairs which is 29.47% of total number demonstrates negative correlation. Highly positive correlation is observed between Sal and Cl (0.999) which indicates a change in the value of salinity will predict a change in the same direction in the chloride value while highly negative correlation coefficient is seen among DO & Turbidity (-0.67), Na & Mg (-0.67).

Table-9: Linear correlation coefficient and regression equation for the pairs of parameters which have significant value of correlation

Pair of Parameters	R	Regression Coefficient		Regression Equation
		A	B	
EC & TDS	0.983	-0.8735322	1.759715	EC = 1.759(TDS) - 0.8735
EC & Cl	0.973	-1.28306	2.728374	EC = 2.728 (Cl) - 1.28306
EC & Turbidity	0.326	6.786184	0.030507	EC = 0.030507 (Turbidity) + 6.786184
EC & Sal	0.974	-1.28364	1.655099	EC = 1.655(Sal) - 1.28364
TDS & Cl	0.961	-0.05973	1.505034	TDS = 1.505(Cl) - 0.05973
TDS & Sal	0.961	-0.06008	0.912996	TDS = 0.913(Sal) - 0.06008
DO & Li	0.479	3.463347	0.003424	DO = 0.003424 (Li) + 3.4633
Turbidity & OG	0.464	-15.7773	0.044165	Turbidity = 0.044165 (O&G) - 15.773
Sal & Cl	0.999	0.000479	1.648431	Sal=1.648431 (Cl) + 0.000479

The linear regression analyses have been carried out for the water quality parameters which generate an equation to describe the statistical relationship between one or more predictor variables and the response variable. The analysis found to have better and higher level of significance in their correlation coefficient.

The regression equations obtained from the analysis are given in the Table 9. The different dependent characteristics of water quality were calculated using the regression equation and by substituting the values for the independent parameters in the equations.

The regression coefficient a and b is calculated by equation (ii) and equation (iii). Finally the regression equation is determined by equation (i) for the relationship between the dependent and independent variable.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 8
August 2017

Sample Name	EC Values				TDS Values			Turbidity Values		Chloride values	
	Experim--ental Values	Predicted Values			Experim--ental Values	Predicted Values		Experim--ental Values	Predicted Values	Experim--ental Values	Predicted Values
		TDS	Cl	Sal		Cl	Sal		O & G		O & G
FW-1	8.98	5.60	3.76	6.2	6.47	4.33	7.15	113	2915.725	5.12	3.10
FW-2	4.19	2.87	2.00	3.30	3.14	2.12	3.50	82	2213.812	3.74	2.26
FW-3	1.77	1.50	1.11	1.84	1.95	1.33	2.20	4.4	456.7644	1.96	1.18
FW-4	11.6	7.09	4.72	7.78	7.95	5.32	8.77	8	538.2769	9.29	5.63
FW-5	1.76	1.49	1.11	1.83	0.97	0.68	1.12	12	628.8464	1.2	0.72
FW-6	18	10.72	7.06	11.65	10	6.68	11.01	187	4591.26	11	6.67
FW-7	19.5	11.58	7.61	12.55	11.3	7.54	12.44	34	1126.978	11.8	7.15
FW-8	7.05	4.50	3.05	5.03	3.59	2.42	3.99	168	4161.055	6.11	3.70

Table 10: The observed and predicted values of physico bio-chemical properties of formation water samples.

The experimental values and predicted values are compared in the above table using the regression linear equation in table 9.

4.0 Conclusion

Formation water samples are collected from the oil-field of Upper Assam Basin. The physico bio-chemical characterization of the formation water samples are carried out and their values are compared with the WHO specification for the disposal of water into the environment. Conductivity, Turbidity, Alkalinity, Hardness, Oil & Grease, Na and K showed values much higher than the safer limits for its disposal. Whereas DO value showed lower values than the permissible limits which indicates low level of free, non-compound oxygen present in water. The correlation study is carried out and the regression equation is developed. This is a useful mathematical tool for the monitoring of the parameters of the water samples. It develops a relationship between the parameters. From the results it is seen that all the parameters are correlated. Thus, the Pearson correlation analysis and regression equation is useful to get fairly accurate idea of quality of formation water by determining a few parameters experimentally.

Acknowledgement

We would like to acknowledge DBT's Twinning Project no. BT/485/NE/TBP/09/04/2013 entitled "**Remediation of produced water from NE oil field by microbial and membrane intervention with modeling of an effluent unit for the recovery of usable water**" for the financial grant and Dibrugarh University for the laboratory facilities

Nomenclature

FW	Formation water
WHO	World Health Organization
BOD	Biochemical Oxygen Demand
DO	Dissolved Oxygen

O&G	Oil and Grease
TDS	Total Dissolved Solids
Sal	Salinity
PW	Produced water
EDTA	Ethylene Di-Amine Tetraacetic acid
KCl	Potassium Chloride
NaCl	Sodium Chloride
$CaCO_3$	Calcium Carbonate
Li_2CO_3	Lithium Carbonate
HCl	Hydrochloric Acid
Na	Sodium
K	Potassium
Ca	Calcium
Li	Lithium
Mn	Manganese
Fe	Iron
Cr	Chromium
Cu	Copper
KOH	Potassium Hydroxide
HCO_3	Bicarbonate
AAS	Atomic Absorption Spectrophotometer

References

1. Y. Du, L. Guan and H. Liang, “Advances of produced water management,” Canadian International Petroleum Conference, 7-9 June, Calgary, Alberta, 2005.
2. S.B. Gogoi, R.K. Sen, A. Rajbongshi, K. Hazarika, “Characterization of Oil field Produced waters of Upper Assam Basin, India,” International Journal of New Technologies In Science And Engineering Vol. 2, Issue. 1, 2015, Issn 2349-0780.
3. K. Guerra, K. Dahm, and S. Dundorf, “Oil and gas produced water management and beneficial use in the Western United States,” U.S. Department of the Interior Bureau of Reclamation, Science and Technology Program Report No. 157, Technical Service Center. Sep. 2011.
4. Z. Khatib, and P. Verbeek, "Water to Value – Produced Water Management for Sustainable Field Development of Mature and Green Fields,” J. of Petroleum Technology, pp. 26-28, Jan., 2003.
5. S.B. Gogoi, and A.S. Tamuli, “Recent Advances in Treating Oil Field Produced Water: A Review,” J. of Petroleum Engineering & Technology, vol. 4, no. 2, pp. 366-370, 2014.
6. K. Jothivenkatachalam*, A. Nithya and S. Chandra Mohan, “Correlation Analysis Of Drinking Water Quality In And Around Perur Block Of Coimbatore District, Tamil Nadu, India.” RASAYAN J. Chem. Vol.3, No.4 (2010), 649-654 ISSN: 0974-1496 CODEN: RJCABP
7. Subrata Borgohain Gogoi*, Animesh Sarma Tamuli, “Recent Advances in Treating Oil Field Produced Water: A Review.” Journal of Petroleum Engineering & Technology, eISSN: 2231–1785, pISSN: 2321–5178 Volume 4, Issue 2.
8. Oliveira EP, Santelli RE, Cassella RJ, et al. “Direct determination of lead in produced waters from petroleum exploration by electrothermal atomic absorption spectrometry X-ray fluorescence using Ir-W permanent modifier combined with hydrofluoric acid”. Anal Chim Acta 2005;545:85–91.
9. Azetsu-Scott K, Yeats P, Wohlgeschaffen G, et al. “Precipitation of heavy metals in produced water: influence on contaminant transport and toxicity.” Mar Environ Res 2007;63:146–67.

10. Kaur G, Mandal AK, Nihlani MC, et al. “Control of sulfidogenic bacteria in produced water from the Kathloni oilfield in northeast India”. Int Biodeterior Biodegrad 2009;63:151–5.
11. Eman A. Emam, Taha M. Moawad, Noha A.K. Aboul-Gheit, “Evaluating the Characteristics of Offshore Oilfield Produced Water”. Petroleum & Coal 56(4) 363-372, 2014, ISSN 1337-7027.
12. Du, Y., Guan, L. and Liang, H., “Advances of produced water management”, Canadian International Petroleum Conference, 7-9 June, Calgary, Alberta, 2005.
13. Veil, J. A., Pruder, M. G., Elcock, D. and Redweik, R. J., "A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Coal Bed Methane", prepared by Argonne National Laboratory for U.S. Department of Energy, National Energy Technology Laboratory, Jan., 2004.
14. Joel, O. F.,Amajuoyi, C.A. and Nwokoye, C. U., "Characterization of formation water constituents and the effect of fresh water dilution from land rig location of the Niger Delta, Nigeria", Journal Applied Sci. Environ. Management, 14 (2): 37 – 41, 2010.
15. Guerra, K., Dahm, K. and Dundorf , S., "Oil and gas produced water management and beneficial use in the Western United States", U.S. Department of the Interior Bureau of Reclamation, Science and Technology Program Report No. 157, Technical Service Center. Sep. 2011.
16. Al-Haleem, A. A., Abdulah, H. H. and Saeed, E. A.-J., "Components and treatments of oilfield produced water", Al-Khwarizmi Engineering Journal, 6 (1): 24 - 30, 2010.
17. Jacobs, R. P. W. M., Grant, E., Kwant, J., Marqueine J. M. and Mentzer, E., “The composition of produced water from shell operated oil and gas production in the North Sea”, In: J. P. Ray and F. R. Englehart, Eds., Produced Water, Technological /Environmental Issues and Solutions, Plenum Press, New York, 13-21, 1992.
18. Consequence of Temperature, pH, Turbidity and Dissolved Oxygen Water Quality Parameters, Vijay S. Kale, International Advanced Research Journal in Science, Engineering and Technology ISO 3297:2007 Certified Vol. 3, Issue 8, August 2016
19. A Study On The Estimation Of Hardness In Ground Water Samples By Edta Tritrimetric Method, P.Ramya, A.Jagadeesh Babu, E.Tirupathi Reddy and L.Venkateswara Rao, International Journal of Recent Scientific Research, Vol. 6, Issue, 6, pp.4505-4507, June, 2015
20. Ibanga, U. A. (1992). Statistics for Social Sciences. Jos: Centre for Development Studies, University of Jos.
21. Sami G. Daraigan , Ahmed S. Wahdain , Ahmed S. BaMosa and Manal H. Obid 2011“Linear correlation analysis study of drinking water quality data for Al -MukallaCity, Hadhramout, Yemen” International Journal of Environmental Sciences, Science and Technology (HUST),Mukalla , Hadhramout, Yemen
22. Maiwada Samuel and Lawrence Ethelbert Okey, “The Relevance And Significance of Correlation in Social Science Research” International Journal of Sociology and Anthropology Research Vol.1, No.3, pp.22-28, November 2015
23. J.A. Veil, M.G. Pruder, D. Elcock, and R.J. Redweik, “A White Paper Describing Produced Water from Production of Crude Oil, Natural Gas, and Coal Bed Methane prepared by Argonne National Laboratory for U.S. Department of Energy,” National Energy Technology Laboratory, Jan., 2004.
24. Bansal, KM; Caudle, DD (1999). “Interferences with Processing Production Water for Disposal”, 9th Produced Water Seminar, Houston, TX, Jan. 21-22.
25. Johnsen, S. et al., Seventh SPE International Conference on Health, Safety and Environmet in Oil and Gas Exploration and Production, 2004, Calgary, Society of Petroleum Engineers, Richardson, Texas.