Salinity Evaluation of On-Site Drilling Wastes at Bi-Hassan Oilfield, North Iraq.

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Abstract

Salts like sodium chloride or potassium chloride are often added to drilling mud system to protect sensitive formations; especially when an oil well is drilled through a salt dome. One major concern with the burial of drilling wastes is the waste potential like salts migration of all directions. In this study, forty samples of total waste (before burial) and the same number of soil (after application of burial on-site disposal method) have been collected from four drilling sites at Bi-Hassan oilfield. Total dissolved solid (TDS), electrical conductivity (EC), sodium adsorption ratio (SAR), pH, chloride mass were determined in all samples in order to identify weather these sites containing high salts levels.

It was found, that most samples have EC and SAR values higher than of standard levels. This salinity will adversely impact vegetation, land and groundwater. Otherwise, no environmental effects will be expected from soil analyzing after adding soil to the wastes since the EC and SAR values are less than 4 mmhos/ cm and 12 respectively.

Key words: Drilling wastes, salts, salinity, electrical conductivity.

الخلاصة

غالبا ما تضاف أملاح كلوريد الصديوم وكلوريد البوتاسيوم إلى نظام طين الحفر لحماية التكاوين الحساسة, وخصوصا عندما يكون يحفر البئر النفطي خلال قبة ملحية. إن مخلفات الحفر لها خطورة تكمن في فعاليتها, إذ ان لها القدرة على الهجرة الى جميع الاتجاهات. في هذه الدراسة تم جمع 40 عينة من مخلفات الحفر الكلية, وجمعت 40 عينة أخرى من التربة من نفس المواقع ولكن بعد عملية دفن مخلفات الحفر بالتربة. جمعت هذه العينات من اربعة مواقع حفر في حقل باي حسن النفطي.

تم تحديد نسبة الاملاح الذائبة الكلية والتوصيلية الكهربائية ونسبة امتزاز الصوديوم والدالة الحامضية, وكذلك تم تحديد كتلة الكلورايد في جميع العينات لتشخيص المستويات الملحية العالية.

لقد وجد ان اغلب العينات (للمخلفات الكلية قبل دفنها) تمثل توصيلية كهربائية ونسبة امتزاز الصوديوم اعلى من المستويات القياسية.ان هذه الملوحة تسبب تلوث بيئي شديد للنباتات والاراضي والمياه الجوفية, وعدا ذلك فان تحليل التربة المضافة الى مخلفات الحفر بعد دفن تلك المخلفات, تشير الى انه لا يتوقع ان يكون هناك تاثير بيئي لان القيم المستحصلة للتوصيلية الكهربائية ونسبة امتزاز الصوديوم هي اقل من 4mmohs/cm او 12 على التعاقب.

الكلمات المفتاحية: مخلفات الحفر, الأملاح, الملوحة, التوصيلية الكهربائية.

Introduction

Pits or reserve pits are used to temporarily dispose of drilling wastes. Some of these wastes can potentially impact the environment which depends on materials and their concentrations and the biotic community that are exposed. The pits usually are closed after the drilling processes have been completed.

The wastes generally compose of two phases, liquid and solid. Some of liquid phase may be evaporate, and other discharge to the land and may be reach to the surface water by different transportation agents. A part of solid phase may spread and contaminate the adjacent land, while the other part being buried on-site. The most common of these wastes are heavy metals, hydrocarbons and salts. These contents especially salts migrate to all directions including upward and downward(McFarland *et al.*,, 1990).The application of saline fluids to soil may result in a number of effects, depending on the natural and application rate of the saline fluids(Lintott *et al.*, 2003). Salt in low concentration equal or similar to the natural occurring levels in a known ecosystem is essential to the whole health of plants and animals; otherwise can cause adverse impact. The abnormal salt concentration can affect the physical properties of soil by causing compaction which eventually makes air, water and nutrients reach to the roots in limit, decreasing the soil permeability and increasing the osmotic pressure of the soil solution(Munns & Termatt, 1996; Agriculture and Agri-Food Canada, 1999; Howat, 2000). For the most drilling mud, sodium has the greatest potential impact in environment from the onshore disposal in pits(Miller, 1978). The charge of water having high concentration of sodium chloride can impact aquatic organism and cause fetal death(Mount *et al.*,1993).

In general, for pits containing high level of salts or hydrocarbons, regulations may require the use of an impermeable pits liner to prevent leaching(Roberts & Johnson, 1990).

Oil production in Iraq is concentrated in two main areas, northern Iraq around Kirkuk, and in the south around Basrah. Many product locations are around Kirkuk, one of them is Bi-Hassan which current study is curried on. Bi-Hassan location have 57 oil wells and the estimated production capacity 100 000 bpd (United Nation of Environmental Programme, 2003).This study has been carried on four oil wells of Bi-Hassan oilfield (Figure-1) as an additional contribution to environmental pollution studies, and to examine the best concept in dealing with such on-site disposal option.

Field Applications and Sampling

The composition of the drilling mud were monitored in the 12 inches and 8.5 inches sections of all wells where saturated salt mud have been used, while in the other sections 17.5 inches and 6 inches the using mud were fresh water bentonite. No oil-based mud was used to drill any of those selected wells.

Forty samples of total wastes taken from the pits of four wells at Bi-Hassan oil field, north of Iraq (Figure1) after all drilling activities were stopped. The on-site disposal wastes were buried with few meters of soil; then thereafter, other forty samples of soil (taken from the same pits after buried) were collected. In the case of waste sampling, a total waste samples have been taken instead of fluid samples or solid samples because the fluid and solid phases are disposed together. Five samples were taken randomly of maximum 30 cm depth from each site and composite to represent one receiving soil sample.

It is interesting to know that the added soil was mixed with the waste regardless of the known ratio which is (3/1), i.e., three volumes of soil to one volume waste. Sampling points of one waste pit is shown schematically in Figure1.

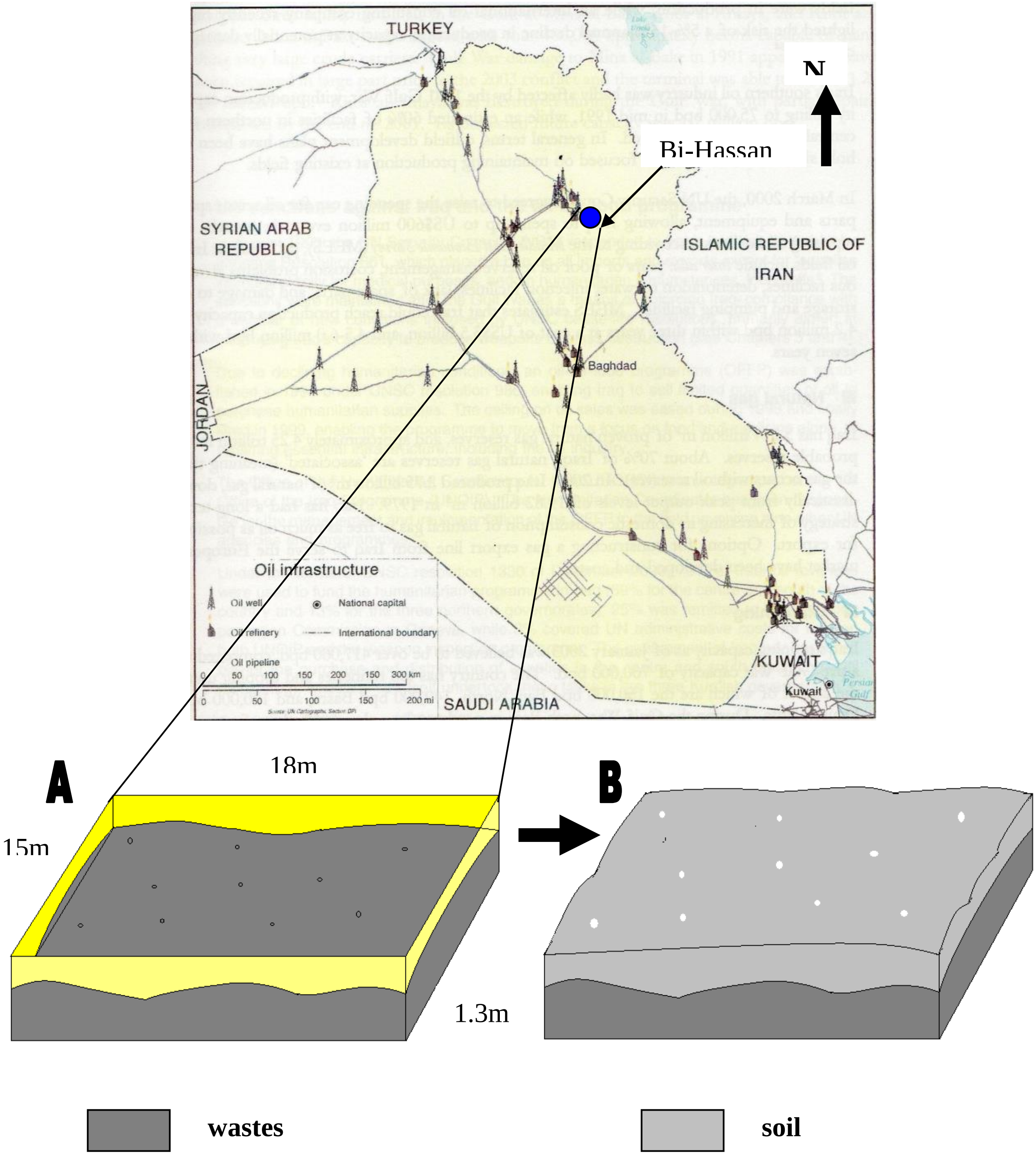

Figure-1: Location map shows typical pit filled by wastes before burial (A), and the same pit after burial with soil (B). The small black circles on surface of waste (A) and the white circles on surface of soil (B) represent the location of samples.

Methods and Mathematic Relations

The all collected samples were chemically analyzed for Na, Ca and Mg by use atomic adsorption spectrophotometer at chemical laboratories of the north oil company and chemistry department of university of Baghdad. Electrical conductivity (EC), total dissolved solid (TDS) and pH were measured directly by EC, TDS, pH meter (Table-1). Many ways are known to measure the salinity and all included measuring EC and sodium concentration(U.S. Salinity Staff, 1954; American

Petroleum Institute, 1989b). Chloride was determined by titration against $AgNO_3$ (Table-1). The values of Na, Ca, and Mg are used to calculate sodium adsorption ratio (SAR) by the following equation(American Petroleum Institute, 1989b):

$SAR= Na/ [(Ca + Mg)/2]^{1/2}$ …………… (1)

Where concentrations of the ions are expressed in Millequivalents per liter (meq/l)

$SAR= 0.0435 Na/ [(0.0499 Ca + 0.08229 Mg)/2]^{1/2}$ ………(2)

Where concentrations are expressed in Milligrams per liter (Mg/l)

The total dissolved solids content (TDS) have a relationship with EC as following(Mtchobanoglous & Burton, 1991):

TDS= A*EC ……………. (3)

Where A is an empirical constant equal of about 640 (cm .mg/mmhos/ liter).

To predict the mass of chloride at any trace elements in waste or soil, one can use(Vickers, 1990):

$Mass (Kg) = [V * Cl * WBD * (Sat/100)]/10^6$………. (4)

Where:

V= volume of solid waste (m^3)

Cl = chloride concentration of saturated paste (mg/l)

WBD = wet bulk density of solids (Kg dry solids/m^3 wet solids)

Sat = percent saturations of saturated paste (%)

10^6 = 1000000 (mg/kg)

Results and Discussion

As mentioned before, forty samples of total waste were collected from pits (ten samples for each pit). The results of EC, TDS, SAR, pH and Cl values are summarized in Table-1. The minimum and maximum values confirmed the acceptable range of variation. These results reveal there are no preferential differences between the three pits (a, b and c), whereas they show somewhat high result of pit d (Table-2). This can be strongly related to mud composition and additives which were detected locally in the active mud system besides that the drilling operation was done through a formation having water with a high salt concentration if the TDS content is above 2800 mg/l, salt can buildup in the soil(Vickers, 1990).

Values of Table-3(American Petroleum Institute, 1989b) are used to compare with the obtained results. Similarly, value of SAR greater than 12 is used to indicate the impact of sodium on soil. High sodium levels (i.e. SAR>12) in soil solutions can cause calcium and magnesium deficiencies in plant(American Petroleum Institute, 1989b). A level of salinity that will not adversely impact land or groundwater is one at which EC less than 4 mmhos/cm (Table-3). The values displayed in Table-1 are not satisfied with this condition due to obtained EC results. Also the values of TDS are more than 2800 which mean that we are dealing with excessive presence of brine in the soil. This undesirable amount of salt is sureness by value of SAR greater than 12 (The general acceptable level in soil). Salt concentration below of 1000 mg/l is considered acceptable value and can improve growth of some plants. So the salt impact on plant and soil will arise primarily from an excess salt concentration as observed from highest levels in Table2.

The dimensions, volumes of waste pits and chloride mass are illustrated in Table-4. From this Table the total chloride mass in the whole pits area (approximately 1017 m^2) is about 2241 kg. This value exceeds the maximum allowable loading limit that must be less than 1600 kg/ha(Alberta Energy and Utilities, 19963). The chloride mass values of Table-4 are identical to what can be concluded from Table-2 about present salinity situation. After application of burial on sit disposal, additional sampling was required to monitor the ability of above disposal process in decreasing the salt concentration to allowable levels. The results of Table-5 illustrate the acceptance of salinity values with standard levels. Obviously, data of Table-5 show the possibility of practicing such on-site disposal method to achieve the desired levels in salt reduction. In other words, all values of EC, SAR, TDS and chloride have no adverse effect on environment.

In General, EC values less than 4 m mhos/cm is confident with the levels proposed by provincial salt guidelines that indicate soil quality is reduced to "poor" in saline soil with EC greater than 5 m mhos/cm.

Conclusions

1. The primary data of sampling (i.e. total waste sampling) indicate high salt concentrations which may be related to a variety of reasons; among of them excessive usage of chlorides in the drilling mud systems, and bad storage and dealing with some materials especially mud additives.
2. The EC, SAR, Cl and TDS values of soil illustrate that a mixture of subsoil with pit wastes was made at the intended mix ratio. As a result, no environmental effects will be expected from such disposal option provided that no hazardous or toxic materials will be mixed with the waste (hydrocarbons for example)
3. Generally, no environmental impacts will be happened since the EC and SAR values are less than 4mmhos/cm and 12 respectively.
4. Field observations show that the most effective way to reduce the environmental impact of pits and then after on-site disposal is to minimize the total volume and/or the toxic fractions of waste generated. This can be achieved through many activities such as making changes in how different materials are stored, managed and practiced and keeping different types of wastes segregated and should never be mixed.
5. If there is any uncertainty about the drilling mud and its additives, then the drilling waste must pass the toxicity assessment before this type of disposal is approved.

Table-1: Results of total waste samples

Pits	Parameters	Number of analyses									
		1	2	3	4	5	6	7	8	9	10
A	EC (mmhos/cm)	7.9	7.8	6.0	6.8	8.5	8.2	7.9	7.2	7.8	7.9
	TDS (mg/L)	5150	4800	5000	5150	5175	5190	5200	5200	5100	5035
	PH	8.1	8.7	8.6	8.8	8.3	9.0	8.4	8.5	8.4	8.2
	SAR	17.9	16.8	15.0	16.9	16.8	17.4	17.6	18.2	17.6	17.8
	CI (mg/L)	2402	2308	2310	2100	2200	2300	2400	2350	2280	2500
B	EC (mmhos/cm)	8.6	9.0	9.4	8.9	9.8	9.5	8.8	9.2	10.1	8.7
	TDS (mg/L)	4920	5150	5585	5500	5480	5305	5500	5605	5600	5580
	PH	8.7	8.2	8.4	8.3	8.4	8.5	9.1	8.4	8.5	8.5
	SAR	22.0	22.4	19.9	22.5	23.5	26.1	24.0	21.6	26.5	25.5
	CI (mg/L)	3180	3050	2950	2900	3000	3100	3150	3140	3180	3200
C	EC (mmhos/cm)	9.1	9.5	9.2	8.5	8.6	9.2	8.8	9.8	8.6	8.7
	TDS (mg/L)	5100	4950	5105	5250	5260	5250	5300	5195	5280	5210
	PH	8.3	8.8	8.6	8.5	8.4	10.1	8.6	8.6	8.4	8.7
	SAR	24.5	19.9	24.5	22.5	23.5	26.5	24.0	27.1	26.0	26.5
	CI (mg/L)	2300	2350	2260	2200	2410	2400	2250	2260	2510	2310
D	EC (mmhos/cm)	8.9	8.8	9.3	9.4	9.1	11.2	10.5	9.0	10.1	8.7
	TDS (mg/L)	5980	5910	5800	5900	5910	5840	5950	6190	5830	5800
	PH	8.9	8.8	8.3	8.7	8.9	8.8	9.0	8.9	10.4	8.3
	SAR	20.2	24.0	24.8	25.5	27.5	29.2	28.6	21.5	24.6	26.1
	CI (mg/L)	3700	3610	3750	3580	3720	3750	3640	3690	3900	3710

Table-2: Minimum , maximum and average of total waste samples , n= number of samples.

pit	n	EC(mmhos/cm)			TDS (mg/L)			PH			SAR			Cl(mg/L)		
		Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.
A	10	6.0	7.6	8.5	4800	5100	5200	8.1	8.5	9.0	15.0	17.2	18.2	2100	2315	2500
B	10	8.6	9.2	10.1	4920	5412	5605	8.2	8.5	9.1	19.9	23.4	26.5	2900	3085	3200
C	10	8.5	9.0	9.8	4950	5190	5300	8.3	8.7	10.1	19.9	24.5	27.1	2200	2325	2510
D	10	8.8	9.5	11.2	5800	5901	6190	8.3	8.9	10.4	20.2	25.2	29.2	3580	3705	3900

Table-3: Effect of Electrical conductivity (EC) on crops (after API, 1989b).

EC range (mmhos/cm)	Effect
0 - 2	Negligible
2 - 4	Yield of very sensitive crops impacted
4 - 8	Yield of many crops impacted
8 -16	Only tolerant crops still produce
> 16	Only very few tolerant crops still produce

Table-4: Total waste volume and chloride mass in studied areas.

Pit	Waste pit dimensions			Volume (m^3)	Chloride mass (kg)
	Length (m)	Width (m)	Depth (m)		
a	16	15	1.2	288	392
b	17	15	1.3	331.5	601.33
c	18	14	1.4	352.8	482.3
d	18	15	1.3	351	764.66

Table-5: Results of the soil samples after burial process.

Pit	EC (mmhos/cm)	TDS (mg/l)	PH	SAR	Chloride (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)
a	1.2	775	6.0	2.90	225	135.8	26.2	144.6
b	1.1	710	6.1	3.21	280	138.1	35.8	160.4
c	1.0	650	5.8	3.46	290	142.5	38.2	180.2
d	1.4	910	6.2	3.5	450	146.5	40.5	190.8

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