On-Site Disposal and Burial of Pit Wastes (Two Southern Iraqi Oil Fields)

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Abstract
On-site pit is the most common option that may be used to dispose drilling wastes. The contents of these pits vary, depending on the lithology of formations drilled and the drilling mud ,and different chemical additives.
Eighty samples of mud (sludge) and eighty samples of water have been collected from ten pits of two Iraqi oilfields(North Rumaila and South Rumaila/southern Iraq) and were chemically analyzed for metals Cr, Pb,As, Zn, Fe, Mn,K , Na,Ba, Ca, Mg,$SO4^{=}$,and Cl^{-} in order to determine the quality and quantity content of studied reserve pits
Inefficient equipment, using toxic materials for various drilling processes, absence of regulations for the design and monitoring of pit during and after drilling operation, and leaking and spilling from many rig equipment, these factors contribute and cause a local environmental impact at the drilling sites.
This study confirmed the need for an alternative options that known globally instead of earthen pits such as closed-loop drilling systems to manage drilling mud and cuttings .

Keywords: pit, oilfields, drilling, heavy metals.

طمر او دفن مخلفات الحفر و التصريف الموقعي

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الخلاصه:
الحُفَر الموقعية هي الخيار الأكثر استخداما في التخلص من مخلفات حفر الآبار النفطية. تتغير محتويات هذه الحُفَر اعتمادا على صخارية التكوين المحفور وسائل الحفر ومختلف الإضافات الكيميائية . تم جمع 80 عينة طينية (وحلية) و 80 عينة ماء من عشر حفر تعود لحقلين من حقول النفط العراقية (الرميله الشمالي و الرميله الجنوبي /جنوبي العراق)و حللت العينات كيميائيا لمحتواها من العناصر ,Mn,Ca,Mg,As, K , Na, Ba, Cr, Fe, Pb, Zn وكذلك الايونات السالبة ($SO4^{=}$, Cl^{-}) وذلك لغرض تحديد المحتوى النوعي والكمي لحُفَر الحفظ تحت الدراسة. إن المعدات غير الكفوءة واستخدام المواد السامة في مختلف عمليات الحفر و غياب ضوابط تصميم ومراقبة الحُفر أثناء وبعد عملية الحفر والنضوح والتسريب من العديد من معدات البرج النفطي،هذه العوامل تساهم وتسبب تأثير بيئي موقعي في المواقع المحفورة.أكدت هذه الدراسة الحاجة إلى استخدام بدائل عالميه كبديل عن الحُفَر الأرضية مثل انظمه الحفر المغلقة ألدوره لتنظيم أطيان الحفر والقطع الصخرية .

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Introduction

Earthen pits(or reserve pits) which excavated adjacent to drilling rigs are the most common option used for the disposal of drilling mud and well cuttings in an oil field. The American Petroleum Institute(API) assumed that 68 percent of the drilling wastes are disposed onsite through evaporation and burial with an estimation of 273 million barrels of drilling wastes were disposed onsite in 2008[1]. The contents of reserve pits depend on the type of drilling mud used, the formation drilled, and other chemicals added to the mud circulation system during the drilling process[2].

The drilling mud that circulate through the well and return back to the surface may contain a variety of metals (e.g., arsenic, cadmium, chromium, copper, lead); diesel oil (the most common base oil used); grease; and various other hydrocarbons and organic compounds.

Oil-based mud (OBMs) have a greater potential for adverse environmental impact due to arise of higher quantities of potentially toxic hydrocarbons such as benzenes and polycyclic aromatic hydrocarbons (PAHs).

Many additives and chemicals are used during the drilling process and often contain toxic substances such as barite as weighting agent and arsenic as a biocide to prevent the growth of bacteria and some additives are used with no reference to their toxic effect.

Produced or formation water is another source of contamination found in drilling site. This water virtually contains impurities that may include dissolved solid (primarily salt and heavy metals), formation solid, suspended and dissolved organic materials, carbon dioxide, and hydrogen sulfide [3]. It may also contain low levels of naturally occurring radioactive materials (NORM) [4,5].

When drilling operation is completed, reserve pits fluids are allowed to dry and remaining solids are encapsulated with the reserve pit synthetic liner and buried in place[6].A survey conducted by the U.S. Environmental Protection Agency (EPA) and the American Petroleum Institute (API) found that liquids in some pits contained chromium, lead and pentachlorophenol at hazardous levels [7].

Some materials may also be entered to the pit during and after drilling which include caustic soda, rig wash, diesel fuel, wastes oil from machinery and other refused [8]. Salts, like sodium or potassium chloride is a form of unwanted components of drilling fluid at disposal time. The new options for solving both drilling and drilling waste problems has gained increased support through the implementation of the famous 5R waste minimization hierarchy to reach the goal of zero discharge drilling wastes [9,10].

Absolutely, to avoid any problems associated with pit volumes, pit size should be designed according to well depth. The average pit volume for wells less than 4000 ft in depth is approximately 3600 barrels (bbl) and for wells greater than 15000 ft in depth is more than 15000 bbls [11].

Finally, pitless drilling or closed-loop drilling reduces the volume of drilling waste by 60 to 70 percent, recycles drilling fluids, and reduces drilling costs [12,13].

The aim of this study is to investigate the quality of different metals found in the pits that can enter and harm the environment. So a large number of samples were collected from twenty pits scattered around many Iraqi oil Field (southern of Iraq) and analyzed chemically for the prepurpose. The heavy metals and other dissolved solids contents in both the water and mud (sludge) phases of these pits were measured through this study. Samples were taken from pits having almost the same contents of drilling wastes according to similarity somewhat in drilling mud and additives used.

Sampling and Field Observations

Eighty samples of mud (sludge) and eighty samples of water have been selected from twenty pits at different drilling sites of Iraqi oilfield and were chemically analyzed for Ca, Mg, Ba, K, Na, As, Cr, Pb, Zn, Fe, Mn, $SO_4^{=}$ and Cl^-.Several aspects have been done to have best dealing with such on-site disposal option as following:

1. The contents of pits vary, depending on the drilling mud and the lithology of formation drilled. Many heavy metals are naturally occurred in rocks in various contents.
2. Bad dealing storage and disposal associated with pits have lead to their being a source of many heavy metals even when these components were detected in the original mud system.
3. Heavy metals found in the pits are often bound to clay particulates with accumulation trend toward the point of discharge which result in non uniform distribution of these metals in the pits. This uniformity must be taken in consideration during sampling [14].
4. The liquid phase in the pits may be evaporated, overflow to the sides, leach directly downward to the ground contaminating soil and groundwater.

5. The composition of the liquid in the pits changes with time from that of the original drilling as a result of many chemical and physical alteration of drilling mud by chemical additives and drilled formation materials.
6. Sampling was carried out with interval at a minimum of one meter from the pit edge with two samples composite as one representative (for the case of sludge phase) and then transported to the laboratory for analyzing directly.

It is important to mention that the dimensions of the observed pits was approximately about 20m * 25m * 2.0m to 25m * 30m * 2.5m [15], which gives an idea about the volume of resulting wastes.

Results and Discussion

The mean of alkali, earth alkali metals, heavy metals and anions concentrations are summarized in table-1. The concentration of Cr, Pb, As, Zn, Fe, Ba, Ca and $SO_4^{=}$ in the mud phase are higher than those in water phase which representing that those were bound to the organic and clay particles and were not readily for dissolving and leaching into the ground and contaminated soil and water, whereas the Mg, Na and Cl^- in liquid phase (water) appear to be higher than of solid phase (clay). The high concentration of Ba and $SO_4^{=}$ ascribes to presence of barite as a chemical additive to the drilling mud.

It can be shown from table-1 that the water accompanying the oil fields in southern Iraq dominated by sodium, calcium and potassium as positive ions and by chloride and sulfate as negative ions.

The high concentration of chromium can be understanding since chromium is a major constituent of many mud additives. It can be used as a gel inhibitor- thinner, a dispersant, a biocide, a corrosion inhibitor and a high temperature stabilizer. Lead, zinc and copper formulate much by weight of pipe dope and have the ability to leach out of the pipe dope and contaminate the drilling fluid. Clearly, an excessive usage has been observed at many of studied drilling sites. It is important to know that zinc has also been found with different concentration which added as zinc salts for density control and as hydrogen sulfide scavengers to minimize corrosion. In addition to the additives, the crude oil is another form of elements and heavy metal foundation in pits. It contains widely varying concentration of various metals among of them Cr, Pb, Fe, Mn, Cu, Ni, Ca and Na .

The heavy metals found in the crude oil are already enter the drilling mud with OBM, or drilling through a formation containing crude oil or if a kick occurs and oil flows into the well and may leaks the surroundings.

In separate work ,the heavy metals contents of four pits affected by different well problems like well kick, lost circulation and pipe sticking were also analyzed and found to vary significantly,figure-1. Also the high content of some metals can be related to many chemical materials used to treat such problems.

Whether or not drill cuttings with their percentage contents of drilling mud and additives, cause harm in the environment, the pit which include these cuttings with associated wastes are covered with a few feet of soil and abandoned.

Table 1- Mean of elements concentration in eighty mud samples and eighty water samples from ten on-site pits of two Iraqi oilfields.

Elements	phase	Concentration (mg/L)		
		Minimum	Average	Maximum
K	mud	5000	10000	16000
	water	1400	1900	2100
Na	mud	1800	2000	2200
	water	2100	2400	2600
Ba	mud	13000	16000	18000
	water	0.6	1.1	1.3
Ca	mud	26000	32000	35000
	water	160	180	210
Mg	mud	35	44	66
	water	63	70	79
Cr	mud	110	180	200
	water	8.5	11.5	14.5

Pb	mud	77	90	110
	water	0.06	0.1	0.12
As	mud	12	20	22
	water	0.01	0.04	0.06
Zn	mud	160	188	200
	water	6.6	7.1	7.4
Fe	mud	22000	25000	29000
	water	0.1	0.6	0.8
Mn	mud	400	500	750
	water	6.0	7.5	8.25
Cl^-	mud	2450	2650	2950
	water	3700	3900	4150
$SO_4^=$	mud	2250	2650	2900
	water	32.2	55.5	66.6

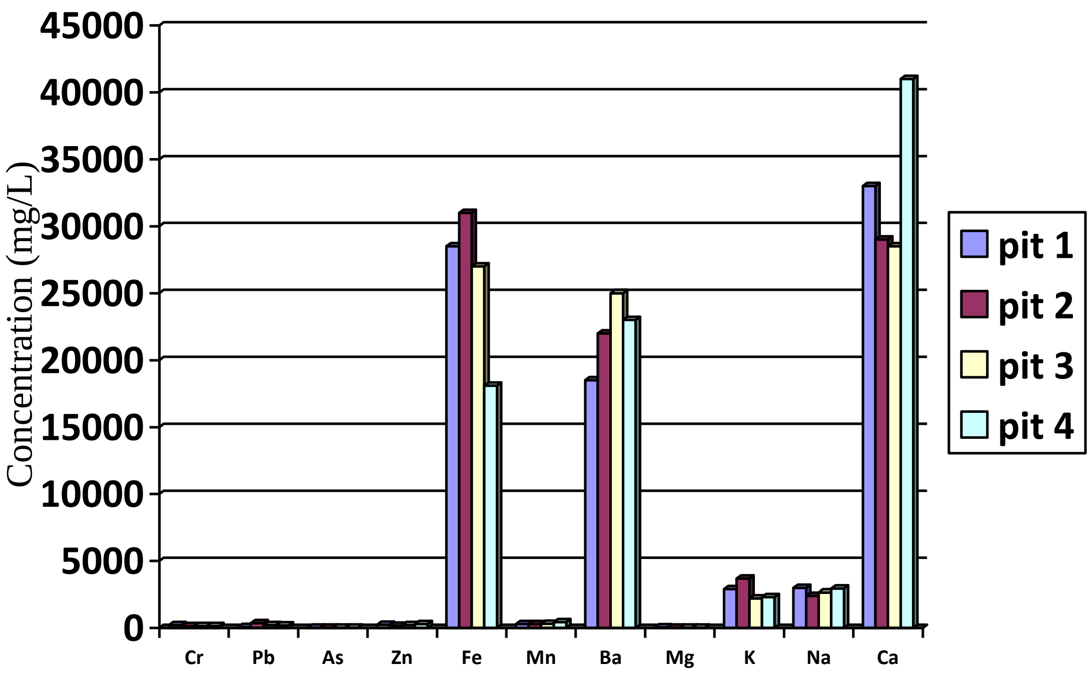

Figure 1- Heavy metal contents of four selected reserves pits.

Conclusions and recommendations:

1- Reserve pits can contaminate soil, surface water, and ground water with metals and hydrocarbons if not managed and closed properly.
2- Generally, it was found that most contamination associated pits involves high salt content from saturated salt mud and /or salt formations, seepage from different equipment on the rig, lead contamination from pipe dope, chromium and barium from excessive usage of chromlignosulfnate and barite respectively, some heavy metals from crude oil as OBM or from well kick problem, and surface water seepage from temporary or poorly designed pits.
3- A specific action plan for handling each and every material used at all drilling sites should be covered by the active waste management plan.
4- Many materials may be added to the pit, either deliberately or in advertently among of them rig wash, diesel fuel, waste oil from machinery and metal and plastic containers.
5- The heavy metals found in pits are not uniformly distributed and often bound to coarse particulates and tend to accumulate near the discharge point.

6- It was found that the metals concentrations in the mud phase were generally higher than in the water phase. This indicates that most of the metals were probably bounded to the organic and clay particles.
7- Inefficient equipment, using toxic materials for various processes, as well as absence of regulations for the design and monitoring of pits during and after drilling operation, these factors contributed and caused a local environmental impact around drilled sites.
8- The regulations must be designed to protect surface and groundwater from contamination.
9- One important option for minimizing the quality of potentially toxic elements is to use less toxic materials for the various drilling processes.
10- Depending on location, oil operators should be allowed a certain time after well completion to close a reserve pit.
11- The information obtained from environmental audits can be used in developing the provided waste management plan, so all materials used or generated within the drilling site must be identified, quantified, and characterized.

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