Application of the Zero-Discharge Method in Managing Wastes of Drilling Operations: A Case Study of Kish Island Gas Field

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ABSTRACT

Oil and gas extraction generates a considerable volume of by products and wastes that must be managed. There are a number of possible environmental impacts from the wastes generated during the well drilling processes. Drilling operations lead to the discharge of wastes into the environment and without preparing a plan to reduce or remove the wastes these materials can have adverse effects in the long run. The most important wastes produced during drilling operations are cuttings, washing water and drilling mud that also include heavy metals. Measuring the volume of produced wastes and identifying the approach adopted for managing wastes are the two chief objectives of this study. The volume of cuttings was measured in cubic meters by using formulas and calculations common in the drilling industry. In addition, the characteristics of liquid waste pit and final disposal areas were also obtained from the Department of Construction Engineering in the National Iranian Drilling Company and were analyzed afterwards. Using this method and 300 cubic meters of cement and sodium silicate 14088 cubic meters of cutting were stabilized and saved in the course of drilling 6 wells with heights of 23526 meters. Furthermore, entrance of 111630 cubic meters of Wastewater into the coral ecosystem of Kish Island was prevented. Regarding waste management in Kish gas field by using the zero discharge method and isolating the final disposal area, no pollutant can enter into the environment and waste management can be practiced in order to prevent penetration of Wastewater and cutting resulted from drilling of oil and gas wells into the soil. Portable earth tanks can be used instead of cement ponds for storing drilling Wastewater.

Key words: zero discharge, mud purifier, drilling fluid, shale shakers, Kish Island.

Introduction

Among the upper sections of the oil industry, drilling and oil production operations can potentially have effects on the environment. These two phases end in a significant amount of wastes and the importance of caring about the environment necessitates finding these pollutants and their production means [1]. One of the serious damages that are faced by the environment are the pollutions resulted from discharge of drilling wastes into the environment. Consequently, the production of wastes resulted from activities and small- and large-scale oil industries have also increased significantly [2]. The waste produced in the drilling industry include: washing effluent, oily soil and sand, and fluids or mud that generally include hydrocarbon and heavy metals. Regarding fluids it should be said that remnant of drilling mud is one of the massive pollutants that results from drilling operations. This pollutant is of two types: water based mud and oil based mud [3]. Due to the increasing growth of drilling exploratory and oil and gas production wells in the world and the increase in the number of strict environmental legislations related to the contamination of cuttings and fluids resulted from...
drilling operations, it seems necessary to use new technologies for managing drilling wastes and reusing them in the industry. By using drilling waste management technology, the amount of pollutions resulted from drilling fluids is reduced to a great extent. In this regard, one of the processes used in the drilling waste management system, which is named the process of “fixation and stabilization process” of drilling cutting, is examined in this paper. This process was used for the first time run in Alaska and was later practiced in Mexican Gulf, North Sea, Mediterranean Sea, and other parts of the world due to the good efficiency. It provides in controlling costs and protecting the environment [1]. In Iran, the stabilization of drilling cutting was practiced successfully in Azadegan oil field for the first time. A number of companies employed fixation and stabilization methods for drilling wastes and use the resulting materials in construction of roads, and buildings [2]. According to the policy adopted by the National Iranian Oil Company and its subsidiary companies for employing efficient waste management systems, the performance of these systems shall be examined monitored carefully. In this research, the drilling waste management system implemented in Kish gas field is studied and its performance is also compared to the performance of a well without a waste management system. Drilling operation for Kish gas field was started in 2009 by deploying Fath 61 drilling rig for drilling six wells and employing the zero discharge system method for practicing fixation and stabilization in the management of the wastes. Waste management

Materials and Methods

2-1- Study Scope:

Kish Island is a subsidiary of Kish district in Bandar Length County in Hormozgan province, which is located in the south of Iran (map 1). This island, which has an area of 90 km², is one of the most beautiful islands of the Persian Gulf and is located at a distance of 18 km from the South Bank of Iran. This oval-shaped island has a length of 15 km and a width of 7 km. In 1968, Kish gas field was defined in the waters of the Persian Gulf by performing a two dimensional seismography. Productivity tests proved the existence of sweet gas in Kangan formation, the upper corridor, Nar, and the lower corridor. With the deployment of Fath 61 drilling rig, the drilling operation for this gas field was started [4] (map 2).

2-2- Methodology:

In order to conduct this research, characteristics of the area under study were obtained from the Internet and were collected, analyzed, and formulated afterwards. Information on the geological and agrological structure of Kish Island was obtained by analyzing geological and stratigraphic reports related to Lavan, Khark, and Kish islands. Stratigraphic information on the geological formations were also obtained by visiting locations under study, analyzing the available drilling information, and interviewing senior geologists operating on Fath 61 drilling rig. In addition, maps were also acquired from the Internet and databases of the Petroleum Engineering and Development Country, which is the employer in the region. Maps of the structure of the disposal area in Kish gas field and information on the characteristics of this field were provided by Construction Engineering Department of the National Iranian Drilling Company. Then, the strengths of the design, its structure and capacity, and the materials used in its construction were identified and recorded. The amount of drilling cutting was measured in cubic meters. The amount of cement and sodium silicate used for stabilization as well as the amount of used pack (poly aluminum chloride) and polymers were determined in cubic meters. Then, the existing waste management system was compared to a well drilled without the use of a waste management system. Next, the outputs of these two processes were expressed. Finally, suggestions are provided based
on the close analysis of problems and experiments of the experts working on the project.

2-3- Calculation Method:

Assuming that the cutting produced by the holes and the fluids smearing the cutting are pollutants, the amount of total contamination can be determined by calculating the cylindrical volume of wells using the corresponding formulas. B1 to B6 are the names given to these wells. Here the method used for managing the wastes of a well named B1 is analyzed based on figures, measurements measures, contamination level, and type of materials used for decontamination. The following formula is used in calculating the amount of soil excavated from a cylindrical hole:

\[
V = \left( \frac{r^2}{1029/4} \right) \times \left( h \times \frac{3}{28084} \right) \times \frac{1}{3}(\text{washout})
\]  

(1)

In the above formula the well diameter is raised to the power of two and is divided by 1029/4. Then, the resulting figure is multiplied by the drilling length and is multiplied/divided by the given figures. When a hole is drilled by a drill it will not exactly have a cylindrical shape because the amounts of cutting produced by drilling a hole are not always the same and the resulting hole does not have one single diameter. In order to make up for this error the amount of drilling cutting is multiplied by 30%. Furthermore, in order to express the amount of additives in cubic meters their bulk density is calculated in kilograms. Then the resulting figures are expressed in cubic meters by using the law of proportions.

<table>
<thead>
<tr>
<th>number</th>
<th>chemical</th>
<th>Specific gravity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>cement</td>
<td>2/7 gr/cm³</td>
</tr>
<tr>
<td>2</td>
<td>Sodium silicate</td>
<td>2/4 gr/cm³</td>
</tr>
<tr>
<td>3</td>
<td>Polyelectrolyte (Polymer)</td>
<td>0/98 gr/cm³</td>
</tr>
<tr>
<td>4</td>
<td>Poly aluminum chloride</td>
<td>1/36 gr/cm³</td>
</tr>
</tbody>
</table>

Table 1: additives Specific gravity in fixation and stabilization system

Results and Discussion

3-1- Choosing the Type of the Drilling Fluid:

Water based fluid is used in drilling gas wells in Kish Island. This type of fluid has limited effects on the environment. It is mainly composed of silt and bentonite, which are chemically safe and inactive materials. Some other constituents of this fluid are biodegradable and some others leave little toxic effects during dilution. The effects of heavy metals such as barium, cadmium, zinc, and lead that exist in drilling fluids are very slight due the restrictions imposed by minerals and accessibility limitations [2].

3-2- Reduction in Fluid Consumption through Simultaneous Drilling:

All the six wells for this project were drilled simultaneously. For example, drilling was started from the B1 Well and its 26" hole. After drilling a hole with a length of 262 meters and placing the casing, similar holes were also drilled in B2 to B6 wells. The fluid made for 26" holes with lengths of 262 meters was used without a waste in drilling six wells. This trend continued in drilling other holes as well. Therefore, this method is useful for reducing drilling fluid consumption and the amount of final wastes [4].

3-3- Employing Solids Control Equipment in Restoring and Recovering Drilling Fluids:

3-3-1- Shale Shakers:

In drilling Kish gas field three shale shakers (Fig. 1) were used for removing solids from drilling fluids. Shale shakers are divided into three types based on their movement type: circular, linear, and oval. Shakers used in the Kish Island have linear and oval-shaped movements. Shakers can handle solids with a size of 74 microns (using mesh screen 200) and particles with a size of 50 microns (using mesh screen 300) [5].

3-3-2- Mud Cleaner:

Mud cleaners are similar to shale shakers in appearance and are used for removing sand from drilling mud (Fig. 2). These devices can remove particles with a size of 30 microns and are composed of three parts: desilter, desander, and shale shaker.
Fig. 1: shale shakers

Particles are removed by rotation of the fluid in cone-shaped waterwheels where centrifugal dominates. During this process lighter fluids separate out through the upper section and heavy solids and a bit of fluid exit through the lower section and discharge to shale shakers. The fluid leaving through the upper section enters into the middle tank for further treatment. Solids that leave the mud cleaner are directed into the cutting coral for fixation and stabilizations [5].

3-3-3- Centrifuge:

This device, which is more efficient for separating purposes, can remove particles with sizes from 3 to 5 microns from the drilling fluid. The fluid enters into the centrifuge. Then, centrifugal force is applied to the fluid and heavier particles stick to the internal cylindrical space of the device and are removed from the fluid. The device has two outlets. One of them, which is placed away from the feed pipe, is used for the treated drilling fluid (liquid discharge), and the other one, which is closer to the feed pipe, is used for separated solids (solid discharge). Three centrifuges were installed and employed at the end of the solids collection area for the Kish project [5].

3-4- Cutting coral:

All the solids leaving shale shakers, mud cleaners, and centrifuges, as well as cement produced through cementing and the contents of the cellar directly flow into the coral (Fig. 3). When the amount of solids reaches a specific point, fixation and stabilization processes are started. Over time, liquids that by any means (for example through the cellar) enter into the coral reach the top and solids are settled. The Overflow is transferred to the liquid waste pit through a channel and the solids undergo fixation and stabilization. By performing an analysis called the Retort analysis and determining the ratio of water and oil to solids in cutting, the amount of cement and sodium silicate required for stabilization and fixation is determined. Normally 50 kg cement and 3 liters sodium silicate is required for one cubic meter of solids. Drilling cutting are mixed with the aforementioned additives for 30 minutes. This allows sodium silicate to react with cutting and create a compound [5].

Fig. 2: mud cleaner

Fig. 3: Cutting coral in Kish gas field
3-5- Fixation and Stabilization:

This process is chiefly aimed at creating highly-stable solid matrix particles and facilitating the transportation, movement, and disposal of wastes resulting from adding materials such as cement and sodium silicate. In the past, cement, fly ash, lime, and calcium oxide were used in the fixation/stabilization of cutting and other wet solids. Recently, the use of 7 types of additives in stabilizing cutting and determining their efficiency as mediums for the cultivation of wetland plants has been studied. These additives include: mica-based average soil, fine mica, three different commercial combinations of recycled cellulose fibers, walnut plaque, and American walnut plaque. Other commercial products with specific composition have been introduced to the market [3]. All the separated solids that enter into the coral are fixed and stabilized using cement and sodium silicate. Cement is added to the existing solids in order to absorb their moisture. On the other hand, sodium silicate is sticky and causes the solids to adhere to each other. Sodium silicate is a white solid that can be solved in water to create alkaline solution. High alkalinity leads to the improvement of conditions for fixation and stabilization of the solid-like structure produced by drilling cutting [2]. Pollutants can seep to the environment when the stabilized solids are in the state of around the area where the waste is inactive and ready for dehydration. Seepage can also occur through the pit, as a result of, for example, washout in the disposal area. Khark limestone, which can be found in Kish Island surface soil layer up to a depth of twelve meters, is equivalent to Bakhtiari conglomerate formation that is found in Zagros Mountains. This limestone is composed of cream solid lime as well as clam, mollusk, echinoderm, etc [6]. Coral limestone is porous and is divided into two types: porous limestone with effective permeability, and porous limestone with ineffective permeability. The latter has a reticular internal structure with vacuities that can be filled with materials. However, since these vacuities are not interconnected, they are not capable of transferring materials to the adjacent tissues. In porous limestone with effective permeability the reticular space is connected to the adjacent tissues. Therefore, this type of limestone is capable of transferring materials from the inside to the porous surrounding. Coral limestone that covers the surface of Kish Island is of this type. In the event of contamination this environment acts as a spongy tissue that distributes the containment contamination between adjacent tissues and facilitates the flow of materials. Therefore, if fixation and stabilization is aimed at preventing any exchange with the surrounding environment over time, this prevention must be guaranteed. In the case of this project, the calcareous structure of the soil in Kish Island provides the means for high alkalinity. Addition of the aforementioned additives makes the fixation of cutting possible and thus no exchange can take place between the prepared concrete clogs and the environment.

3-6- Treatment Area:

Following to fixation in the coral (Fig. 4), the solids are transferred to the treatment area in order to dehydration and solidification before disposal. The Ken test is a method for testing free water in stabilized materials in the drilling area. This test is performed on each series of stabilized cutting before transferring them to disposal areas [5].

3-7- Liquid Waste Pit:

All the effluents Wastewater produced by washing tanks, the cellar, pumping area adjacent to the pumps, cooling processes, devices working on wells, pipes, and rainfall flows into this pit through channels that are made for this purpose (Fig. 5). Concrete is cast into the pit floor and the floor is enclosed with cement walls. Following to the entrance of Wastewater into this pit, the existing solids are settled and the remaining liquid flows into the dewatering unit to be treated and dewatered. The settled solids are also collected by a loader and are transferred to the coral for stabilization. An oil trap is emplaced at the beginning of the liquid waste pit. It is mean to prevent the entrance of hydrocarbons, which are lighter than water, into the pit. Sometimes the volume of petroleum derivates leads to a decrease in the efficiency of this pit and entrance of the liquid waste into the Wastewater pit. In the case of this event another device known as oil skimmer is used for collecting the oil floating on the surface of the Wastewater. The oil skimmer floats on the Wastewater and separates petroleum derivates by rotating on the water surface and taking advantage of the high viscosity of oil compared to water [5].

3-8- Quantity of Produced Solid Waste:

The American Petroleum Institute (API) estimates that about 150 million barrels (i.e., 24000000 cubic meters) of waste resulted from drilling operations in 1995 were produced in offshore wells and solid drilling cutting form about 40 million barrels (i.e., 6400000 cubic meters) of these wastes each year. For example, in the United States wells drilling cutting contaminated with drilling mud are restricted around the well along with Wastewater resulting from washing the drilling rig, rainfall, and liquid wastes stored in the liquid waste pit. When drilling of a well is completed, each fluid stored in the tanks is removed and disposed and the remaining solids are either disposed or sprinkled spread around the well. This method has been employed in drilling oil and gas wells in Iran (Fig. 6) and is still in use in
other places. The average volumes of oil based mud and water based mud required for drilling a well in the southern oil fields (khozestan iran) are 5000 barrels (i.e., 800 cubic meters) and 22000 barrels (i.e., 3520 cubic meters), respectively [5]. Almost 25% of drilling cutting are contaminated with oil derivatives. Assuming that annually 130 onshore wells are drilled, the required amounts of oil based mud and water based mud are 650000 barrels (i.e., 104000 cubic meters) and 2850000 barrels (i.e., 457600 cubic meters), respectively. At the end of the drilling operation the additional oil based mud is transferred to the plants and facilities designed for the treatment of oil based mud in order to be reused. Other water based mud (emulsive and non-emulsive) and fluids resulting from the drilling mud and cleaning of equipment, machinery, and tanks are conducted to earth ponds surrounding the drilling rig (pit). The overall volume of uncontrolled mud that may flow into the ponds is more than 4000 barrels or 640 cubic meters. Moreover, drilling cutting are discharged into earth ponds. In drilling a well with a depth of 3000 meters approximately 1000 to 1500 tons of cutting are produced. The area of ponds is between 1 to 1/5 hectares [5]. Hence, in drilling a well without the aid of waste management an area of 1/5 hectares is wasted. Tables 2 and 3 show the results of measuring the level of pollutants (drilling cutting) removed from drilling fluid using solids control equipment. In addition, the amount of additives used for stabilizing and fixing drilling cutting of the B1 Well is presented and is compared to the amount of additives used in well 458 in Ahwaz. The B1 Well was taken as the sample required for analysis. The drilling operation of well 458 was started in 2011 by installing Fath 59 drilling rig in Ahwaz County. The zero discharge system was also employed with fixation and stabilization purposes in order to manage produced wastes. The materials, equipment, human forces, and methods employed in this system are similar to those of the waste management system used for Kish gas field. Excavation of the B1 Well and well 458 in Ahwaz took the same amount of time while well 458 is 500 meters deeper than the B1 Well and thus the amount of cutting produced in this well is approximately 650 cubic meters more than that of the B1 Well in Kish gas field. About 50 cubic meters of cement and sodium silicate is used for the fixation and stabilization of cutting and thus more cement and sodium silicate is used for fixation and stabilization purposes. The difference between this amount of additives and the amount of additives used for the fixation and stabilization of drilling cutting resulted from excavation of well 458 in Ahwaz is 42 cubic meters [5].

Fig. 4: fixed cutting in treatment area  
Fig. 5: Liquid Waste Pit

Fig. 6: Waste Pit Non-isolated system
3.9-Reuse through Dewatering:

Dewatering is a physicochemical process aimed at separating solid particles from Wastewater resulted from drilling operations. The chemical process of dewatering includes the following three phases: coagulation and flocculation. The reason behind using these materials is that the centrifuge can separate particles larger than 3 microns. Therefore, in order to remove solids smaller than 3 microns from fluids (Wastewater produced by washing and drilling mud), flocculation is used put into use. Flocculation is the process of sticking charged solid particles and formation of larger particles. After the flocculation and coagulation processes are completed, colloidal particles with diameters less than 3 to 5 microns are removed from fluids and are stabilized by going through a mechanical operation in the centrifuge. Tables 4 and 5 show the results of comparison between the total volume of treated fluids and additives used in the B1 Well in Kish gas field and that of well 458 in Ahwaz. The amount of pack and polymer used in well 458 in Ahwaz is 12 cubic meters less than the amount used in the B1 Well in Kish gas field. The amount of water used for cleaning purposes is 5000 cubic meters more than the other one. Another reason for the higher level of water consumption in Kish gas field is that in cleaning the machinery and the lot hosting the drilling rig a one-inch hose is used and therefore too much water is used by the drilling rig and too much Wastewater is produced. In washing Wastewater conduits installed in the drilling rig lot artisans put high-pressure hoses into the conduits in order to remove sediments and empty the conduits. Liquids waste ponds are filled quickly and their empty space is reduced due to the production of too much Wastewater. Therefore, problems are caused for liquid waste management. In order to increase efficiency, decrease water consumption, and make optimal uses of reproducible natural resources washing requirements should be satisfied by using steam. To empty out Wastewater conduits in the area the artisans should use hand shovel and no water. The pond at the top of the well, which stores Wastewater flowing from the drilling platform and other areas, should be evacuated constantly. This is done by using a great amount of water and practicing a traditional method known as the cellar jet method. To empty the cellar a pump or floating pump, which works without water (or too much water, like the cellar jet method), is used. Since water based fluid is used in Kish gas field, the amount the fluid used in the B1 Well is 6400 cubic meters more than the amount of fluid used in well 458 in Ahwaz because about 500 cubic meters of oil based fluid is used in well 458. On the other hand, since the amount of water based fluid required for each well is four times the amount of oil based fluid, these figures indicate that due to the application of methods such as simultaneous drilling and proper fluid treatment by solids control equipment in the B1 Well the fluids are used optimally.

**Table 2:** Total separated solids by solids control in well B1 of Kish island in compared with well number 458 in Ahvaz. [6], [7].

<table>
<thead>
<tr>
<th>Number</th>
<th>Solids</th>
<th>Well number 458 of Ahvaz</th>
<th>Well Number B1 of kish island</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cutting separated by solid controls (m³)</td>
<td>800</td>
<td>553/8</td>
</tr>
<tr>
<td>2</td>
<td>Total solids separated in dewatering unit (m³)</td>
<td>2202</td>
<td>1794/2</td>
</tr>
<tr>
<td>3</td>
<td>Total wells dept (m)</td>
<td>4391</td>
<td>3921</td>
</tr>
<tr>
<td>4</td>
<td>Total drilling time (day)</td>
<td>143</td>
<td>140</td>
</tr>
<tr>
<td>5</td>
<td>Total cutting generated (m³)</td>
<td>3002</td>
<td>2348</td>
</tr>
</tbody>
</table>

**Table 3:** Total volume of cement and sodium silicate was added for solidification in well no. B1 Kish gas field in compared to well no. 458 of Ahvaz. [6], [7].

<table>
<thead>
<tr>
<th>Number</th>
<th>Solids</th>
<th>Well number 458 of Ahvaz</th>
<th>Well Number B1 of kish island</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sodium silicate used (m³)</td>
<td>1</td>
<td>2/38</td>
</tr>
<tr>
<td>2</td>
<td>Cement used (m³)</td>
<td>91</td>
<td>46/95</td>
</tr>
<tr>
<td>3</td>
<td>Total material added to solidification</td>
<td>92</td>
<td>49/33</td>
</tr>
</tbody>
</table>

**Table 4:** Volume of the total treatment fluids in well B1 of Kish gas field in compared well 458 of Ahvaz [6], [7].

<table>
<thead>
<tr>
<th>Number</th>
<th>Matter solid</th>
<th>Well number 458 of Ahvaz</th>
<th>Well Number B1 of kish island</th>
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<tbody>
<tr>
<td>1</td>
<td>Polyelectrolyte (Polymer) (m³)</td>
<td>1</td>
<td>2/49</td>
</tr>
<tr>
<td>2</td>
<td>Poly aluminum chloride (m³)</td>
<td>7</td>
<td>16/9</td>
</tr>
<tr>
<td>3</td>
<td>Solidification additives sum used in dewatering unit</td>
<td>8</td>
<td>19/39</td>
</tr>
</tbody>
</table>

**Table 5:** Value Pack and polymer used in fluids treatment system in well No. B1 of kish in compare with well No. 458 of Ahvaz. [6], [7].

<table>
<thead>
<tr>
<th>Number</th>
<th>mud’s</th>
<th>Well number 458 of Ahvaz</th>
<th>Well Number B1 of kish island</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Oil base mud’s (m³)</td>
<td>495</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Water base mud’s (m³)</td>
<td>1918</td>
<td>8780</td>
</tr>
<tr>
<td>3</td>
<td>Surface waters due to leaching</td>
<td>3760</td>
<td>9825</td>
</tr>
<tr>
<td>4</td>
<td>Total fluid was Dewater (m³)</td>
<td>6173</td>
<td>18605</td>
</tr>
</tbody>
</table>
3-10- Disposal Area:

Disposal areas can be used for disposing drilling wastes and other wastes produced in oil fields (Fig. 7).

The disposal area for the Kish project has a length of 55 m and a width of 70 m. This area is equipped with an inlet with a length of 7 meters. Its walls are 3.2 m high and are made of block. Its volume is has a capacity 15000 m$^3$ and its floor is made of reinforced concrete. Its floor is first covered with a mixture of sand and clay with a diameter of 40 cm. Then, bars are placed into the cast concrete with a diameter of 10 cm. 150 kg of cement is also used in each cubic meter of the surface. Concrete was cast in the upper layer with a diameter of 20 cm and 350 kg cement was used in each cubic meter of the upper layer. In order to fill the gaps between concrete sections polystyrene sealing mastic (plasto profe) was used. In addition, the coral, liquid waste pit, and the treatment area have also these extraordinary structures and characteristics. A cement wall with a diameter of 40 cm surrounds the disposal area and the side of the wall that faces the disposal area is covered with sand and cement plaster layer with a diameter of 3 cm. This layer is also covered with a tar paper, which has a depth of one meter and covers the floor of the disposal area. Compacted earth is used around the outer surface of the wall. Diagram 1 shows the

**Fig. 7:** disposal area is isolated by Reinforced concrete

**Diagram. 1:** Drilling cuttings generated from six wells in each hole

Characteristics of 5 other wells that are located near the B1 Well. Therefore, the results obtained for each of the six wells can be taken into account. During the 840-day drilling operation six wells with lengths of 24000 meters were drilled and drilling cutting amounted to 14088 cubic meters. First, these solids were separated in the treatment system by using 120 m$^3$ of pack and polymer. Then the solids were fixated and stabilized along with other cutting removed through solids control equipment and settling in ponds by using 300 cubic meters of cement and sodium silicate. Assuming that the amount of additives added to the solids is increased, 14508 cubic meters of solids is stabilized and transferred into the final disposal area. Since the area is isolated, the contamination produced as a result of drilling six gas wells is disposed in an enclosed area and cannot reach the outside. 58950 m$^3$ of water used in drilling the wells was treated and returned to the system for mud making or other applications.
Furthermore, 52680 m$^3$ of wasted drilling mud, which is considered a pollutant, was collected and treated during the drilling operations of Kish gas field and in sum 111630 m$^3$ of contaminated fluid (Wastewater and drilling mud) is controlled and disposed safely while its penetration into the coral (lime) ecosystem of Kish Island is also prevented [5]. The conditions in the final disposal area in Kish gas field provide more efficiency compared to the conditions in the southern Azadegan oil field. The drilling operation for the southern Azadegan oil field was started in Hawr Al-Azim wetland in order to utilize the hydrocarbon storages of the area. This operation was performed in 2010 by deploying Fath 86 drilling rig. Waste management is practiced in this oil field by employing the zero discharge method for fixation and stabilization purposes. However, the final disposal area (Fig. 8) is not equipped with an isolated system and thus cement clogs are released in an earthen area. The explanation is The result show that the fixation and stabilization processes are effective for waste management and there is supposed to be no connectivity between cement clogs and the environment. According to the results of previous studies, all the areas of the soil are contaminated as compared to the control soil due to their total petroleum hydrocarbon (TPH) contents, but their total petroleum hydrocarbon contents is less than the standard level (API=500 mg/kg) and only reaches the standard level (492 mg/kg) when oil based fluid is employed. Therefore, this soil is contaminated compared to the control soil but is not contaminated with respect to the standards. The host soil is not contaminated with regard to standards for heavy metals such as cadmium (API=26 mg/kg), nickel (API=420 mg/kg), and arsenic (API=41 mg/kg)[11]. Based on the evidence it can be concluded that the fixation and stabilization process can effectively prevent the exchange discharging of toxic metals and other pollutants to sensitive ecosystems such as Kish island that are encapsulated in solid structures. Moreover, since no isolated system is used in the final disposal area in the Azadegan project, based on the analyses it can be said that no contaminations is found in the soil of this area. On the other hand, utilizing the described disposal area in Kish gas field with its calcareous structure and high alkalinity adds to the efficiency of the waste management system used in this field.

**Fig. 8:** final disposal area in south azadegan project.

**Conclusion:**

1) The fluid used in Kish gas field drilling was a water based fluid, which is more environment friendly compared to oil based fluids.

2) Simultaneous drilling excavation of the holes with the same diameter and formation and reuse of the wastes in drilling equal holes regard to their sizes and their resemblance to the characteristics of the fluid used in the holes provides for maximum reduction in waste fluids. Therefore, further environment contamination and damage of the is avoided while the costs are also decreased.

3) Usage of solids control equipment, petroleum derivatives separators, and other equipment used in managing, treating, and reducing wastes leads to the increasing efficiency of the system because in other systems that do not utilize waste management only shale shakers are put into used.

4) The place for the collection of cutting (the coral), liquid waste collection ponds, treatment areas, and final disposal areas are isolated with reinforced concrete and there is no possibility for washout or entrance of pollutants into the environment or underground waters.

5) Fixation and stabilization of about 14000 m$^3$ of drilling cutting as well as treatment, control, and disposing safely 111630 m$^3$ of Wastewater and drilling mud prevents contamination of the environment and guarantees its safety.

6) Regular and daily tests including the Retort and Ken tests as well as tests performed on water treatment systems provide for approved the performance accuracy of stabilization processes,
reduction in the standard deviation, and growth in
efficiency.

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