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ENVIRONMENTAL CHEMISTRY, POLLUTION & WASTE MANAGEMENT | RESEARCH ARTICLE

An overview of management, recycling, and wasting disposal in the drilling operation of oil and gas wells in Iran

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Abstract: There is large quantity of cuttings which are produced from drilling operations oil and gas wells. Depletion of solid particles in the solid control equipments is allocated as a considerable proportion of wastes. Remaining of waste particles in the system can cause diverse affects in mud function and the occurrence of potentially destructive impacts on the environmental and ecological systems. In the operation process of the new systems, drilling cuttings are separated by solid-state control devices. All their properties are examined and then buried in a solid and fixed state after a solid-state refurbishment operation. Furthermore, all tests are carried out in the liquid phase in the environmental situation, and after being recycled, they are reused or safely buried. The objective of this comprehensive research is to introduce the new design layout, operating principles, equipment, and planning of new wastewater management from the environmental point of view which are based on available information about several drilled wells of Iran that are used for solid-state control systems



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Mr. Afshin Davarpanah is a graduate student of petroleum engineering from Islamic Azad University, Science and Research Branch. His current interests in petroleum engineering sciences include a full-field study of Data Gathering, Reservoir Simulation, History Matching and Prediction. Data gathering stage mainly consisted of Well Logging, Coring, Seismic Survey, Geological Survey, and conceptual investigation on the properties of different drilling fluids and their considerable influence on the environment. What he did at this stage as a petroleum engineer was to simulate and find the unmatched data and resolve the discrepancies.

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PUBLIC INTEREST STATEMENT

Regarding the increasing demand for the utilization of crude oil in numerous industries, petroleum industries would always try to find novel solutions to virtually eliminate the vast expenditures of drilling operational performances. One of the major concerns of drilling industries is to remove waste materials in an appropriate way or change it to the beneficial way of reusing in the operational activities. Thereby, in this comprehensive study, we tried different types of waste disposal and solid removal systems which all of them be operated for a special condition. As it is evident, corral systems, drying-shaker and auger, and disposal sites are the common and proper methods of waste disposal in Iran.

and drilling waste management. Consequently, corral systems, drying-shaker and auger, and disposal sites are the common and proper methods of waste disposal in Iran.

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1. Introduction

Laboratory tests and practical field experience have shown that closely monitoring drilled solids in the mud and minimizing their concentration can result in large savings of both money and time. These savings manifest in three ways: increased drilling rate (fewer days per well), increased bit life, and increased life of mud-pump parts (Davarpanah, 2018; Davarpanah, 2018b; Fornasier, Campo, Djuric, & Obando, 2017; Harthy, Oo, Al-Saqri, & Karim, 2018; He, Chen, Ren, Li, & Liu, 2018; Hossain, Al-Majed, Adebayo, Apaleke, & Rahman, 2017). The key to solids control is minimizing the concentration of “Undesirable” drilled solids. Formation pressures dictate the amounts of weighting agents (barite, calcium carbonate, etc.) that must be present in the mud; these types of solids are necessary and are not considered in this discussion. Undesirable solids are those that become incorporated in the mud during the drilling process, e.g., salt, carbonates, and clays. The accumulation of these types of solids can cause mud property problems (increases in viscosity and rheology, buildup of mud weight, etc.) that in turn decrease the drilling rate, bit life, and the life of mud pump parts (Ismail, Aliasc, Sulaimana, & Zaidi, 2017; Khodja, Khodja-Saber, Canselier, Cohaut, & Bergaya, 2010; Kuznetsov & Suprun, 2017; Laroche et al., 2018). Although small amounts of drilled solids incorporated into a drilling fluid are not generally considered detrimental, serious problems can develop if these particles are continually recirculated. Removal and treatment of drilled solids constitute the major portion of drilling fluid expense. Solids may be classified as coarse particles greater than 2,000 microns, intermediate particles from 250 to 2000 microns, medium particles from 75 to 249 microns, fine particles from 45 to 74 microns, ultra-fine particles from 2 to 44 microns, colloidal particles less than 2 microns, by their particle size, expressed in microns. (A micron is 1/25,400 in., or 1/1100 mm). Treatment of muds that exhibit solids-related problems can involve any or all of the settling, dilution, mechanical separation, chemical treatment processes (Davarpanah, 2018a; Li et al., 2017; Patil & Deshpande, 2012; Platt, Manthos, & Amos, 2018a, 2018b; Rodriguez et al., 2017). According to the regulations and different policies for the removal of wasting in different countries, Iranian oil companies tried several harnessing technologies to virtually eliminate the volume of this waste and reuse the waste materials again in the drilling operational performances. To do this, the hydraulic fracturing operations have the best and optimum way for reusing the waste waters and subsequently reduce the operational costs. However, in the coming decades, the United States has posed strict policies to overcome this issue by updating the regulations and previous legislations such as improvement of separation equipment and reusing of waste water in the hydraulic fracturing to eliminate the vast expenditures of providing water and other materials for separation performances. Thereby, addressing the problem of hazardous and toxic materials is one of the major concerns of petroleum industries which should be taken into the consideration (Sayyadnejad, Ghaffarian, & Saeidi, 2008).

Solids removal by the settling method involves retaining mud in a nearly quiescent state long enough to allow the undissolved solids, which are heavier than water, to “fall out” of the fluid. The relative success of this method depends on several factors such as the size and shape of the particles, the density of the particles, the density of the fluid, and the overall retention time.

The speed of settling can be increased by use of a flocculants to increase the particle size, or by inducing centrifugal force to increase the gravitational effect (Siddique, Kwoffie,

Addae-Afoakwa, Yates, & Njuguna, 2017b). Dilution is most often used as a means of correcting mud properties that have been altered by the accumulation of drilled solids. By this method, the solids are not removed but their concentration is decreased. Since solids continue to build up in the mud as drilling progresses, the problems in mud weight, rheology, etc. usually reappear. Dilution is often expensive for the consumption of the products required to maintain desired mud properties increases, lack of storage space for the increased mud volume often leads to the discarding of hundreds of barrels of valuable drilling mud, and extra cleanup and transportation costs are incurred in environmentally sensitive areas. Mechanical separation devices are available in two basic types: vibrating screening devices (shakers), and systems that use centrifugal force to increase settling rate. Mechanical treatment of solids buildup is often the most practical and cost-effective of the four available methods; it does not alter essential mud properties; it decreases the need for dilution. Generally speaking, the greater the cost per barrel of a given mud, the greater the savings in using mechanical equipment to rectify mud properties. Solids removal equipment systems can consist of any of the following devices; shale shaker can remove solids down to 150 microns with 200-mesh screens, desander/desilter depending on size of cone, can remove 50–70-micron solids, mud cleaner Dual purpose (desilter over fine-screen shaker), can remove solids down to 75 microns and recover some barite, centrifuge can remove colloidal solids down to about 2–5 microns (Li et al., 2017; Platt et al., 2018a; Razmjoo, Qolipour, Shirmohammadi, Heibati, & Faraji, 2017; Siddique, Kwoffie, Addae-Afoakwa, Yates, & Njuguna, 2017a; Usher, Herrington, Kozikowski, & Scott, 2015).

Waste management is considered as the principal issues in the petroleum industries. There are four major parameters: Reduce, Recycle, Reuse, and Recover. In different stages of drilling of oil and gas wells, there is always a different design with regard to the necessity of operations for the construction of drilling fluid, mainly using saline water muds and oily muds with special chemical additives. For example, using oil base mud in the rock formation will always have a 20–30% contamination in terms of drilled mud. In broad terms, the main sources of contaminant in drilling operations consist mainly of waste from drilling fluid which is circulated in the well, drilled piles from submerged landforms which are driven by a flow of mud in a well by mixing drilling fluid, dismantled cement from well cementing operations, fluids used for separation in various operations, and various other discharged fluids such as water used to rinse decontamination equipment and all of which are considered as major pollutants of the environment. However, various factors could influence the production of this waste volume, including the following parameters: the wellbore size, efficiency of solid control equipment, ability of drilling fluid in maintaining and transferring more volumes of drilling cuttings, ability of drilling fluid in preventing the sedimentation, and dispersion of drilled piles. Chemical treatment involves the use of flocculants to drop unwanted solids out of the mud. This type of treatment is not recommended for use with many mud systems; however, it may adversely affect mud properties. The mechanisms of separation of solids from liquids can be classified according to the nature of the forces that cause the separation. (1) External forces are caused by external fields of acceleration, such as gravity, electrostatic, and magnetic fields. (2) Internal forces occur within the fluid itself, e.g., inertia, diffusion, electrostatic field of charged particles, and thermosphere. (3) No forces is a screening principle; filtration can also be regarded as an extreme case of screening (Brady et al., 2017; Harthy et al., 2018; Ismail et al., 2017; Kuznetsov & Suprun, 2017; Rodriguez et al., 2017).

Although numerous studies are reported in the literature to emphasize the importance of removing waste disposals and solid particles which are hazardous for the environment, in this study, we try to investigate the new techniques to control the volume of wastes in the drilling wells. According to the findings of this study, corral systems, drying-shaker and auger, and disposal sites are considered as the most common recycling systems which are provided the proper result in the drilling of Iranian's oilfield.

2. Methodology (Operational Performances)

2.1. Execution program of solids control system

In order to achieve the desired goals of management on the high volume of waste from drilling wells in oil and gas, Iran's National Drilling Company, with the focus of Drilling Fluid Administration and with the principle of Zero Discharge, has executed five major solutions in five stages. The order of importance is reduction in waste from production source, reuse and recycle waste, treatment of waste produced by existing methods, recycling waste in a way that is recovered from new material waste, the final disposal of the waste is safe and safe for the environment which is clearly depicted in Figure 1.

2.2. Various components of solid control system

Preventing destructive effects on plant and animal life always require an examination of environmental conditions and criteria by 100%. Investigating the performance of the drilling industry in the recent years has shown more attention to environmental laws and considerations by utilizing new technologies and equipment to minimize the amount of waste material during the well-drilling processes. In this regard, the new technology of solid control and waste management Drilling involves three key factors within the framework of environmental, economic, and operational requirements in all stages of planning, implementation, and conclusion, all activities of this field comply with the above five steps in the principles of system operation.

2.3. Drying-shaker and auger

Oil base mud for drilling rigs is commonly used because of the high economic value of this fluid group on the one hand and on the other hand, due to certain environmental hazards that the material constituting this flower threatens the environment (Tsydenova & Bengtsson, 2011). Following is the use of drying-shaker and auger on the agenda. By placing this equipment under the vibrant shaft when using an oil base, the cuttings are cut from the well to a more dry state and repel more of the flowers they have in contact with.

2.4. Corral

Corral is a place to accumulate all the distracting material that is removed from the mud by solid-state control devices. This environment is located at the front and in the material drainage site from solid-state control discharges (Figure 2). A capacity of approximately

Figure 1. Solids control system and drilling waste management due to its importance.

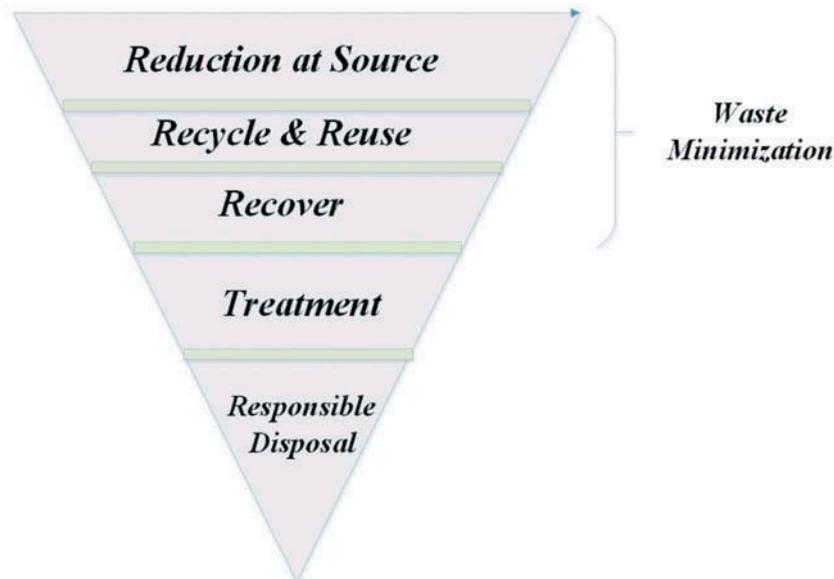


Figure 2. Corral equipment.



130 cubic meters can produce a suitable response for a large volume of mud in a critical condition. Discharged particles in this site are ultimately managed by stabilizing chemicals such as cement and sodium silicate.

2.5. Disposal site

After the fixation on the corral excavated drill runs, the treatment process takes place and new shapes are formed for the cutters. At the end of the site, disposal is considered to be the final fissile material of the fixed residue, and the particles are transferred to the test site after the molding in new tissue and success.

3. Results and discussion

Solid Management System consists of a total of auger and drying-shaker and separate environments under the corral and disposal site titles, which are embedded to the final management on solids that were drilled at the time of drilling with a base of oil and water. Considering the results of the experiments such as can test, Retort test, Sheen test, etc., on the one hand and on the other hand, it is necessary to spend enough time to form a suitable mold for the particle fringing. Always the final burial site of drilled piles is different from the mud base of the mud bed, with the drilled mud bloom. The encapsulation of oil particles in the base oil and the removal of salt saltines in saltwater muds are among the most important fixation goals of the plant that is obtained by using cement and sodium silicate in drilling rigs. The production of a high volume of waste from oil and gas drilled wells requires a comprehensive monitoring and management to properly control the way this material is disposed of. By investigating the process of drilling wells in Iran, it can be seen that the presence of some barriers leads to challenges in controlling drilling solids, which we are discussed briefly:

- Environmental problems leading to the use of oily mud based for excavation of shaly formations.
- Use of certain non-environmentally friendly chemicals in making drilling muds.
- Use of drainage basins obtained from drilling muds with an approximate area of 200×200 and a depth of 1–2 m (Figure 3).
- Fluid discharger with drilling and solid content of mud due to inadequate monitoring of solids control process.
- Remaining high volume of felled material in the ponds surrounding the deck location which leads to possible damage to water resources in the region.

Figure 3. Area of drainage basins obtained from drilling muds.



4. Conclusion

Due to the fact that increasing use of hydrocarbon energy in today's world and Iran's remarkable progress in the drilling industry are of equal significance. Regarding the major concern of drilling industries to remove the hazardous materials from the environment, the optimum techniques should be taken into consideration to virtually eliminate the disposals. Consequently, the use of new technologies in solid control and waste management will be of great help to the drilling industry in terms of increasing the workforce in a variety of economical and economical environments.

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Competing Interests

The authors declare no competing interests.

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References

- Davarpanah, A. (2018). The feasible visual laboratory investigation of formate fluids on the rheological properties of a shale formation. *International Journal of Environmental Science and Technology*, 1–10. doi:10.1007/s13762-018-1877-6.
- Davarpanah, A. (2018a). The integrated feasibility analysis of water reuse management in the petroleum exploration performances of unconventional shale reservoirs. *Applied Water Science*, 8(2), 75. doi:10.1007/s13201-018-0717-7
- Davarpanah, A. (2018b). A visual investigation of different pollutants on the rheological properties of sodium/potassium formate fluids. *Applied Water Science*, 8(4), 117. doi:10.1007/s13201-018-0762-2
- Fornasier, F., Campo, M., Djuric, A., & Obando, D. (2017). *Designing environmentally conforming drilling fluids: Challenges and considerations in Latin America*. Paper presented at the SPE Latin America and Caribbean Petroleum Engineering Conference, 17–19 May, Buenos Aires, Argentina.
- Harchy, A. M. A., Oo, Y. H., Al-Saqri, S. M., & Karim, A. M. (2018). The effect of technology and digitalization on the quality management system among Omani oil and gas drilling company. *International Journal of Applied Engineering Research*, 13(5), 2331–2337.
- He, L., Chen, Y., Ren, L., Li, J., & Liu, L. (2018). Synergistic management of flowback and produced waters during the upstream shale gas operations driven by non-cooperative stakeholders. *Journal of Natural Gas Science and Engineering*, 52, 591–608. doi:10.1016/j.jngse.2018.02.018
- Hossain, M. E., Al-Majed, A., Adebayo, A. R., Apaleke, A. S., & Rahman, S. M. (2017). A critical review of drilling waste management towards sustainable solutions. *Environmental Engineering & Management Journal (EEMJ)*, 16(7), 1435–1450.
- Ismail, A. R., Aliasc, A. H., Sulaimana, W. R. W., & Zaidi, M. (2017). Drilling fluid waste management in drilling for oil and gas wells. *Chemical Engineering*, 56, 1351–1356.
- Kuznetsov, V. S., & Suprun, I. K. (2017). Reduction of an adverse impact during well drilling by means of drilling waste usage. *Journal of Ecological Engineering*, 18(2), 12–15. doi:10.12911/22998993/68211
- Laroche, O., Wood, S. A., Tremblay, L. A., Ellis, J. I., Lear, G., & Pochon, X. (2018). A cross-taxa study using environmental DNA/RNA metabarcoding to measure biological impacts of offshore oil and gas drilling and

- production operations. *Marine Pollution Bulletin*, 127, 97–107. doi:10.1016/j.marpolbul.2017.11.042
- Li, W., Zhao, X., Cai, B., Liu, J., Yan, C., Guo, W., ... Huang, D. (2017). *Integrated treatment and disposal of waste drilling fluid onshore China: Laboratory investigation and process design*. Paper presented at the SPE Abu Dhabi International Petroleum Exhibition & Conference, 13-16 November, Abu Dhabi, UAE.
- Patil, R. C., & Deshpande, A. (2012). *Use of nanomaterials in cementing applications*. Paper presented at the SPE International Oilfield Nanotechnology Conference and Exhibition, 12-14 June, Noordwijk, The Netherlands.
- Platt, R. V., Manthos, D., & Amos, J. (2018a). Estimating the creation and removal date of fracking ponds using trend analysis of Landsat imagery. *Environmental Management*, 61(2), 310–320.
- Razmjoo, A., Qolipour, M., Shirmohammadi, R., Heibati, S. M., & Faraji, I. (2017). Techno-economic evaluation of standalone hybrid solar-wind systems for small residential districts in the central desert of Iran. *Environmental Progress & Sustainable Energy*, 36(4), 1194–1207. doi:10.1002/ep.12554
- Sayyadnejad, M., Ghaffarian, H., & Saeidi, M. (2008). Removal of hydrogen sulfide by zinc oxide nanoparticles in drilling fluid. *International Journal of Environmental Science & Technology*, 5(4), 565–569. doi:10.1007/BF03326054
- Siddique, S., Kwoffie, L., Addae-Afoakwa, K., Yates, K., & Njuguna, J. (2017a). Oil based drilling fluid waste: An overview on environmentally persistent pollutants. *Paper Presented at the IOP Conference Series: Materials Science and Engineering*, 195, 012008. doi:10.1088/1757-899X/195/1/012008
- Tsydenova, O., & Bengtsson, M. (2011). Chemical hazards associated with treatment of waste electrical and electronic equipment. *Waste Management*, 31(1), 45–58. doi:10.1016/j.wasman.2010.08.014



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