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ENVIRONMENT FRIENDLY TECHNIQUE FOR DECONTAMINATION OF NATURALLY OCCURRING RADIOACTIVE MATERIALS (NORM) CONTAMINATED EQUIPMENT WITH LOW-LEVEL WASTE (LLW) IN AN EGYPTIAN OIL FIELD

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ABSTRACT

Oil and gas production processing operations have been known to produce a large amount of NORMs at elevated concentrations as by-product waste streams. Also, TE-NORM wastes from the oil &gas industry may generate radiation exposure levels, which require attention and continuous monitoring during NORM decontamination of oil and gas equipment. In this work: 1) we study and analyze the TE-NORM contamination from the theoretical and technical point of view during production of oil and gas in an Egyptian oil-field. This is to improve the existing decontamination techniques used in decontamination of NORM facilities to minimize the produced waste as much as possible, and to evaluate the effectiveness of the developed techniques by measuring the NORM existence level before and after decontamination process. For this sake: a) decontamination before disposal has been conducted, either by: Conventional wet High Pressure Jetting Water (HPJW) and/or Ultra High Pressure Jetting Water (UHPJW) technologies or unconventional dry technologies. b) "Dry" decontamination method and the related decontamination facility as a dedicated tool for tubing and other small installation's decontamination using abrasive blasting machine will be discussed. "Dry" technologies may offer an advantage of (almost) zero secondary radioactive waste generation. 2) Continuous monitoring during NORM decontamination of oil and gas equipment has been conducted. Workers were monitored for one year on three months basis using the TLD badges. Ten workers were divided into two groups, working back to back 15 days on 15 days off in field basis, for around 10 working hours/day. All recorded personal doses were within the occupationally acceptable dose limits (20 mSv/Year). Most of workers were exposed to doses within the range of 700 – 1000 µSv/3 months, two readings were away of this range, but even though still within the occupationally acceptable dose limits. It was found that used protective measures against external and internal contamination helped in the protection of the workers against NORM hazards as well as minimizing the NORM contaminated wastes using the dry decontamination technique to very far extent in comparison to high pressure jetting water technique which had an positive impact on the environment regarding the radioactive decontamination in oil and gas working environment.

Keywords: NORM, Pipes Decontamination, Egyptian Oil field, scale, Radiation Safety, Environment protection.

Introduction

It is well-known that many raw materials contain traces of natural radioactive nuclides and hence are referred to as Naturally Occurring Radioactive Materials (NORM). They are encountered e.g. in the phosphate industry, in the mineral sands industry and the oil and gas industry (IAEA, 2003).

Part of a successful NORM management strategy is the ability to decontaminate equipment; which has become contaminated with NORM. The removal of relatively insoluble NORM scale, adhering to equipment surfaces, requires aggressive agitation of the surface to remove it. The control of NORM contamination removed from contaminated equipment and the protection of workers during the decontamination process is achieved primarily by engineering controls that must be supported by administrative procedures and personal protective equipment (PPE) (Bruhl, 1990). NORM contaminated equipment cannot be released for sale or re-use as it has enhanced levels of radioactivity, which can lead to radiation exposure of workers, the general public and the environment, if not managed appropriately (ALISA, 2013). The goals of the decontamination process are the safe removal of NORM from the equipment, delivering insignificant radiation exposure to the workers, and without impacting the environment by spreading NORM contamination (Desouky, 2018). The main radiation protection problems associated with the NORM scales are irradiation of staff in areas where scales are deposited and internal contamination by those removing the scales.

Surface contamination of pipes and other facility components by naturally occurring radionuclides is a common issue in oil and gas industry (El-Ghazaly, 1997). Usually, the reservoir water contains Group II (Periodic Table) cations of calcium, strontium, barium and radium dissolved from the reservoir rock. As a consequence, the produced water contains the long-lived radium isotopes Ra-226 ($T_{1/2}$ = 1620 y) from the U-238 series and Ra-228 ($T_{1/2}$ =

5.75 y) from the Th-232 series. The parent nuclides U-238 and Th-232 are not mobilized with the formation water of the reservoir rocks. Due to operation history, pipes, valves and further components of the production facilities are more or less contaminated with Ra-226, Ra-228, and their daughter nuclides (Eylander, 1997). In some oil/gas fields, also Pb-210 (T1/2 = 22.3 a) is dissolved in considerable amounts in the reservoir water, resulting in an elevated surface contaminations with Pb-210. Another mechanism that may lead to high Pb-210 contamination in components of oil and gas production facilities is the decay of Rn-222 T1/2 = 3.8 d), which is highly soluble in oily reservoir waters (IAEA, 2013).

At a typical oil/gas production site in Eastern desert of Egypt, large volumes of contaminated tubing, pipes, fittings,….*etc*. resulting from dismantling of production wells and other facilities were accumulated over years. To manage these contaminated equipment in compliance with national regulations and international recommendations for the clearance dose limits, aiming to maximizing the benefits of stockpiled assets by decontamination for the unrestricted reuse.

Norm Contaminated Equipment

As per the international and local laws and regulations, NORM contaminated equipment must be handled, transported, stored, maintained or disposed in a controlled manner proportional to their activity and compliant with related guidelines. Protocols are needed to ensure that equipment is not released or handled without controls to protect the worker and prevent contamination of the environment. The following should be considered the minimum requirements for the control of NORM-contaminated equipment with activity above exemption thresholds (EAEA, 2006 & AECS, 1998).

Equipments hould

- Be decontaminated prior to release for unrestricted use
- Be stored only in designated storage areas
- Be tagged or clearly marked as NORM contaminated.
- Be handled only by employees trained in NORM hazards an disusing PPE
- Not be sent for maintenance /repair to workshops without informing the workshop that the component is contaminated with NORM.
- Be disposed of only in an approved NORM disposal facility.
- Be decontaminated only in an approved NORM decontamination facility or according to an approved decontamination protocol.
- Open sections of equipment, i.e., flange or pipe ends, etc., should wherever possible be adequately covered by heavy-gauge UV-stabilized plastic or other suitable materials to ensure that NORM material does not leak from the item.
- Routine checks on all stored NORM –contaminated equipment should be undertaken to ensure that the integrity of the protective measures is adequate.
- Detailed and verifiable records should be maintained of all stored NORM contaminated equipment

Once verified as free from NORM contamination, the equipment may be re-used sent for repair/servicing in the normal manner or sold or disposed of as scrap.

Materials and Methods

Available Conventional Decontamination Methods

Various decontamination methods are being applied on and off the site, the choice of method depending on the type and size of the components and the characteristics of the contaminating substance. Methods range from removal of bulk sludge from vessels followed by rinsing with water to the application of chemical or mechanical techniques. The methods of specific operational importance are described briefly as following:

Decontamination By Chemicals

Chemical methods are applied and are being developed further for down-hole scale removal and scale prevention (Almasri, 2003 & Cowie, 2008). If scale prevention has failed and the extent of scaling interferes with production and/or safety, chemical methods are also applied for removal of scale from the production system. The chemicals used are based on mixtures of acids or on combinations of acids and complex agents. Usually, the primary reason for *in-situ* de-scaling is to restore or maintain the production rate rather than to remove radioactive contamination. Nevertheless, effective prevention of scaling causes radionuclides mobilized from the reservoir to be carried by the produced water through the production system rather than being deposited. Chemical removal of scale also removes the radionuclides contained in the deposits, resulting in a liquid stream containing the radionuclides from the dissolved scale. In many cases, some dissolution of the metal of the component being decontaminated cannot be avoided which is remarkable disadvantage of the method as well as the large volume of the waste which considered as hazardous waste need a special treatment.

Decontamination By Water Jetting

High Pressure Water Jetting (HPWJ) has been shown to be effective for the decontamination of components from oil and gas production. Water pressures of 10-250 MPa are used, which necessitate the use of special pumps and safety measures. In principle, it can be applied on the site and offshore as well as onshore, but its effective and radiological safe application needs special expertise and provisions to obtain the correct impact of the jet, to contain the recoiling mist and to collect and dispose of the water as well as the scale. HPWJ is usually applied at a limited number of specialized establishments and service companies that are authorized to operate decontamination facilities (Janssen, 1997).

Decontamination of tubulars is carried out with the aid of long HPWJ lances fitted with special nozzles that are moved through the whole length of a tubular while the water with the scale is collected at the open ends. It is relatively easy to contain the recoiling water from tubulars. The application of HPWJ to the outer surfaces of components is strongly complicated by the mist produced by the impact of the jet. In the open air this will cause the spread of the radioactive contamination removed from the object and in enclosed spaces it greatly reduces visibility, also it has adverse environmental impact as it enhance the waste volume by producing large amounts of NORM contaminated water.

Decontamination By Melting

The melting of metallic components contaminated with NORM will separate the metals from the NORM nuclides. The latter end up in the slag or in the off-gas dust and fume. Decontamination by melting is being applied at dedicated melting facilities, but only on a small scale as it is very complicated process and also have adverse impact on environment, rather than by this way we lose the contaminated assets values (IAEA, 2013).

Decontamination By Sand Blasting

This cleaning process is often used on difficult to clean items. Specially designed sand blasting cabinets with HEPA filtration systems can be effective at removing residual NORM scales or films that other cleaning processes could not remove. This method has two major disadvantages; the additional sand volume generated in the cleaning process poses an extra waste volume; and the huge amount of dust generated due to the blasting operation (Cowie, 2012).

Need For New Decontamination Technology

The process of selecting decontamination technologies is based mainly on very important factors that affect decision making; a cost/benefit analysis to be performed to see if it is actually worth decontaminating the equipment or facility. This analysis is usually accompanied by extensive experimental work on selected samples from the facility in view of characterization before the final decision of a decontamination technique is made, as well as complying with the HSE requirements, local regulatory authorities recommendations and international standards for protecting the workers and environment within the safe acceptable margin from radiation protection point of view.

To achieve a good decontamination factor (DF), a decontamination process must be designed for on-site application taking into account a wide variety of parameters, some of which are the followings: type of contaminated equipment's/ facilities to be decontaminated :pipe, tank, etc. ; operating history of the plant; type of material: carbon-steel or stainless steel , etc.; type of surface: rough, porous, coated, etc.; type of contaminant: scale, sludge, loose, etc.; and the specific radioactivity of the NORM involved; ease of access to areas/equipment to be decontaminated, external or internal surfaces to be cleaned; regulatory requirements and decontamination factor required; time required for application; proven efficiency of the process for the type of contamination in the facility.

Other factors which are important in selecting the method, but which do not affect the decontamination factor are: availability, cost and complexity of the decontamination equipment and consumables; need and capability of treatment and conditioning of the secondary waste generated; potential exposure to hazardous materials and/or chemicals used in the decontamination process; occupational and public doses resulting from decontamination (justification of the practice); other safety, environmental and social issues; availability of competent certified staff.

For all of these reasons and earlier mentioned factors and the indeed need to an enhanced/ developed decontamination technology that match the regulatory requirements and comply with the Egyptian E&P company's needs; as the currently available techniques are mainly mechanically decontamination techniques which based on the use of the High Pressure Water Jetting (HPWJ) and the advanced version which is recently got in use is the Ultra High pressure Water Jetting (UHPWJ), so the type of technique to be developed here in this study is the mechanical decontamination in dry condition to minimize the secondary waste volume and to maximize the benefit of the used materials in decontamination process to be recyclable aiming to produce minimum waste volume of more than 95% pure waste.

The main concept of the technique is the Abrasive Blasting technique almost same like sand blasting technique, but here we will try to avoid the dust generation in the sand blasting method , minimizing the waste volume as well as enhance the feasibility of the process by using a recyclable blasting material to be cost suitable to task.

(i) Abrasive-Blasting Decontamination Technique

Dry abrasive-blasting systems, commonly used in the conventional industry, which may provide very high decontamination factors. The longer the operations are continued, the more effective they are. In our study we will try to mechanically separate the radioactive NORM waste from the surface of the contaminated equipment /facilities and retrieve back the blasting media with maximum ratio could be achieved. The dry abrasive-blasting technique, commonly called sandblasting or abrasive jetting, has been used in non-nuclear industries since the late 1800s. This technique, which uses abrasive materials suspended in a medium that is projected onto the surface being treated, results in a uniform removal of surface contamination. Compressed-air or blasting turbines are normally used to carry the abrasive. Removed surface material and abrasive are subjected to proper collection and segregation mechanism to separate the radioactive waste and the retrievable intact blasting materials. Recirculation of abrasives allows the minimization of secondary waste.

Dry abrasive-blasting is applicable to most surface materials except those that might be shattered by the abrasive, such as glass, transit or Plexiglas. Application on aluminum or magnesium should also be avoided due to the risk of dust explosions. It is most effective on flat surfaces and because the abrasive is sprayed, it is also applicable on hard-to-reach areas.

(ii) Abrasive Media Used

As most of contaminated equipment /facilities in oil and gas industry such as: vessels, tanks, pipes …etc; are made of carbon steel so the selection of the effective abrasive media is based on the fact that we have to keep the structure of contaminated facility unharmed in the same time effectively removed the contaminants' scale and sludge, according to the following table:

Results and Discussions

A comprehensive measurement survey campaign has been conducted to segregate the contaminated equipment according to the dose measurements that showed the dose rate was up to 10µSv/h in few points, but usually the readings were between double background value (i.e 0.5

µSv/h and 5µSv/h) were measured with conventional dose rate monitors. Table 1 illustrates the surface contamination levels for a contaminated facilities (549 tubing of size 3½"), has been measured with a surface contamination monitor of type CoMo-170.

Table 1: Shows the surface contamination level (before decontamination) Versus percentage of total tubing count

Sr.	% of total tubing count	Surface contamination level in cps
1	2.3	251
2	3.2	498
3	3.6	560
4	5.3	98
5	6.0	150
6	6.7	260
7	8.2	113
8	10.4	320
9	10.9	79
10	11.8	169
11	14.8	255
12	16.8	150

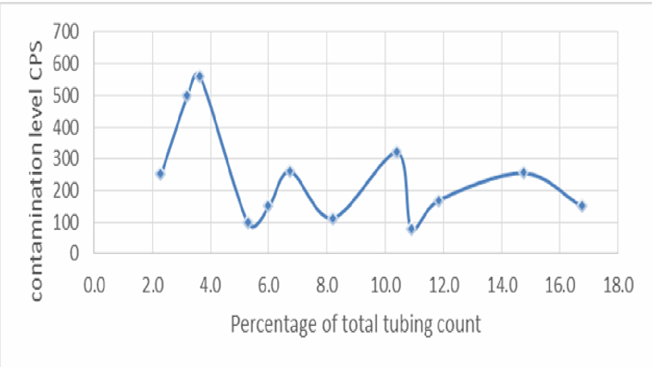

Fig. 1: The surface contamination level versus percentage of total tubing count

Decontamination Facility

The decontamination facility is presented in a closed loop blasting facility. Its components are installed in 40' container (as blasting room) and directly connected alongside one 20' container the "Blasting Machine Container" was placed, which contains the Problast machine, the control system, the filter system for exhaust air, and the equipment for collection of blasting waste into 200 L drums as an extension.

The measurement of contaminated equipment were conducted in a previously prepared designated area in the vicinity of the decontamination container using output-rack and an additionally erected rack for clearance measurements.

Furthermore, a "Personnel area" was provided. It is sub-divided into a "white area "and a "black area", which is used for changing clothes and contains sanitary equipment for regular use, and a shower for incidental use. An abrasive material (garnet), the choice of which depends on specific circumstances, is propelled on the surface at high speed. The most common method of abrasive blasting uses compressed air to propel the grit material from a blast pot through a blasting hose to a nozzle that is manually controlled by the operator. For the cleaning of inner pipe surfaces, the nozzle is inserted into the pipe up to the rear end, which is connected and tightly sealed with the collecting adapter of the abrasive recovery system. Due to the vacuum prevailing in the collecting adapter, the abrasive material is recovered and conveyed to the reclaim unit. The produced waste (scale debris, deteriorated garnet) is collected in a disposal drum.

Fig. 2: blasting of tubing with lance unit

Fig. 3: internal pipe blaster tool

Contaminated Equipment

Many contaminated equipment are accumulated over time as a result of dismantling during maintenance projects for the facilities, it includes: valves, fittings, bended pipes,….*etc.* Also, tubing and pipes with diameters from 2 7/8" to 12" with original lengths of about 10m were measured then racked waiting to be mobilized into the unit of blasting room appropriately for blasting of both internally and externally. This is in addition to 115 pieces of valves, fittings,…, *etc.* were measured, identified as NORM contaminated and racked to be ready for decontamination process. In total, about 1220 tubing of previously registered as contaminated with NORM were managed, including about 70 tubing that were cleared as uncontaminated on the basis of respective measurements. About 1130 tubing were cleared after successful blasting, and about 20 tubing had to be re-blasted after been chemically treated, due to their oily or tar – like contamination, which could not be removed by abrasive blasting only with acceptable effort. And the 115 separate pieces of valves and fitting were totally cleared out of NORM contamination and were ready to be used again after functional inspection.

Dry Decontamination Method

Generally, contaminated objects can be cleaned with a large range of technologies. Always the comparisons made between mechanical, chemical and other technologies, each with its own advantages and disadvantages in terms of which technology fit more to the subject, and there is no overall best technology. Some objects are best decontaminated with a mechanical method, while others are best treated with chemical methods. We chose to use "dry" technologies, which in effect are mechanical technologies. The term "Dry" is used to clearly distinguish it from the chemical technologies, which in general use large quantities of liquids and therefore are referred to as "wet" technologies. Generally spoken, the production of secondary waste is larger for wet/chemical technologies as the residual waste generated by chemical technologies needs more treatment than the waste generated by mechanical technologies. Dry abrasive blasting is used in a wide range of industries for many different purposes including the removal of rust, scale, paint etc., and for various forms of surface preparation. In total, about 1220 tubing of previously registered as contaminated with NORM were managed, including about 70 tubing that were cleared as uncontaminated on the basis of respective measurements. About 1130 tubing were cleared after successful blasting, and about 20 tubing had to be re-blasted after been chemically treated, due to their oily or tar-like contamination, which could not be removed by abrasive blasting only with acceptable effort. And the 115 separate pieces of valves and fitting were totally cleared out of NORM contamination and were ready to be used again after functional inspection.

Results

Surface contamination level was re-measured after the decontamination completed, found most of decontaminated tubing were in the background level except 20 tubing (3.6 % of total tubing count) were relatively measuring high readings that were treated chemically then re-blasted again, were a successful lowering down of the contamination level to be within the background level has been shown.

Table 2: Surface contamination level (after decontamination) versus percentage of total tubing count

Sr.	% of total tubing count	Surface contamination level in cps
1	2.3	18
2	3.2	19
3	3.6	9
4	5.3	10
5	6.0	9
6	6.7	12
7	8.2	11
8	10.4	21
9	10.9	14
10	11.8	15
11	14.8	12
12	16.8	19

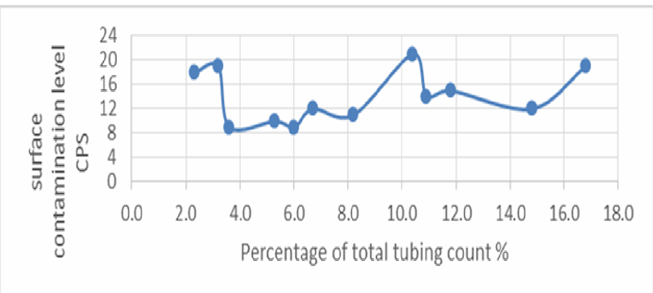

Fig. 4: Surface contamination level (after decontamination) versus percentage of total tubing count

2.1 Cleaning By Descaling Technique

The tubes under investigation, were cleaned by the descaling technique appears to be totally clean as judged from dose-rate readings. Most of measurements taken by survey meter were all indistinguishable from the ambient background for all tubes cleaned and investigated.

Table 5: Dose- rate measured in µSv/h of each pipe under investigation before decontamination

	At 1m	At 4m	At 7m	At 10m
P-1	6.82	6.12	5.72	6.71
P-2	8.21	7.96	8.11	8.38
P-3	15.15	14.73	15.25	15.25
P-4	11.32	11.21	11.42	10.72
P-5	3.13	2.84	3.25	3.37
P-6	1.55	2.12	2.24	1.99
P-7	12.74	11.88	9.82	10.51
P-8	7.82	7.35	6.83	7.14
P-9	4.71	4.52	3.92	4.18
P10	2.22	2.31	1.81	2.15

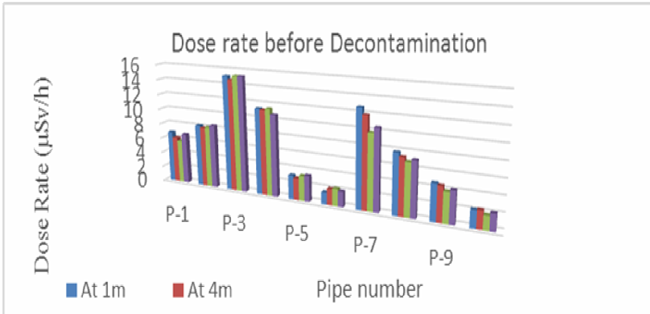

Fig. 5: Dose-rate measured of each pipe under investigation before decontamination

Table 6: Dose- rate measured in µSv/h of each pipe under investigation after decontamination

	At 1m	At 4m	At 7m	At 10m
P-1	0.23	0.19	0.27	0.28
P-2	0.18	0.21	0.34	0.27
P-3	0.39	0.41	0.37	0.25
P-4	0.40	0.38	0.29	0.31
P-5	0.12	0.17	0.21	0.20
P-6	0.09	0.12	0.12	0.10
P-7	0.21	0.19	0.25	0.27
P-8	0.25	0.19	0.13	0.24
P-9	0.09	0.11	0.15	0.13
P-10	0.09	0.08	0.10	0.13

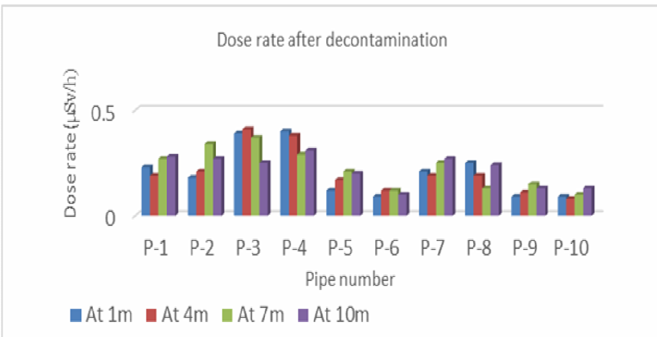

Fig. 6: Dose- rate measured in µSv/h of each pipe under investigation after decontamination

TLD Measurements of Exposed Workers

Personal exposure dose rate for the workers were monitored for one year on three months basis using the TLD badges. In the study, ten workers were divided into two groups working back to back 15 days on 15 days off in field basis, for usually around 10 working hours/ day. The results of personal exposure dose-rate showed that; all the personal doses are within the occupationally dose limits (20 mSv/Year). Most of workers were exposed to a dose in the range of (700–1000) µSv/ 3 months. Two workers showed very low /high readings comparing to others. Further investigations showed that; those 2 employees were working back to each other and one of them was in sick-leave for 70 days in the third quarter (low reading) and his work was covered by his relief for the same period (the high reading), which caused these unusual exposures doses but even though still within the occupationally dose limits.

Table 7: Absorbed doses for workers exposed to NORM over one year in µSv/h

No. of workers	Jan-17	Apr-17	Jul-17	Dec-17
1	785	850	810	790
2	930	790	885	760
3	990	1012	810	905
4	710	960	320	890
5	810	1031	795	893
6	878	1075	560	785
7	685	915	758	965
8	674	951	730	912
9	689	1007	1560	965
10	985	1012	674	745

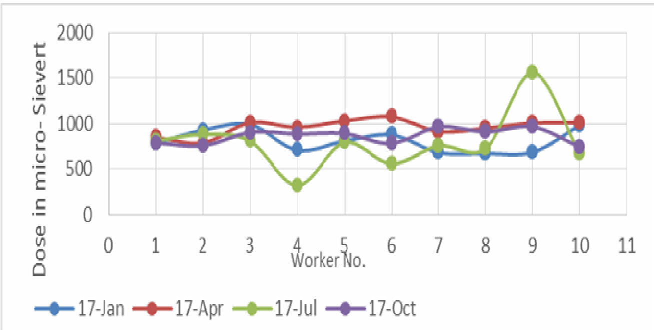

Fig. 7: Absorbed doses for workers exposed to NORM over one year in µSv/h

Discussion

In the present work, TE-NORM deposits have been analyzed, focusing on the safe decontamination alternatives, from the theoretical and technical point of view during and after the production process of oil and gas in an Egyptian oil field. By studying and discussing the NORM contaminated facilities in oil and gas we found that; hard scales formation is widely distributed in all parts of the field oil installations. This formation urges us to have a NORM Decontamination Facility (NDF) with a technology that provide minimum waste volume, reasonable time frame, low cost and in the same time doesn't use the water as decontamination media. By the NDF hard scales can be removed from contaminated equipment and tubular, stored as waste materials in standard storage barrels in a controlled storage area; transferred for previously prepared temporarily NORM storage area as per the national laws and standards (Law # 7/2010 for Egypt) and international standards.

To manage scrap in compliance with national regulations and international recommendations for the clearance of steel scrap, a comprehensive study was initiated comprising initial radiological survey for the contaminated equipment and assessment of the effectiveness required for stockpiled scrap, the development and test of a clearance measurement method straightforwardly applicable under field conditions with an acceptable expenditure of time, the study and comparison of technically feasible cleaning techniques were taken in consideration, and execution of the cleaning operations and clearance of decontaminated scrap for unrestricted reuse on small scale. Sludge, oily sediment that is produced during cleaning operations of oil separators, storage tanks and other surface equipment, is considered as NORM waste. These wastes were found to contain less activity than the hard scale. Companies have implemented NORM regulations by ENRRA, and currently using plastic lined disposal pits that are constructed in each area for temporary storage. NORM contaminated soil; the third main NORM waste produced by the Egyptian oil and gas industry is contaminated soil. Radioactivity, mainly radium isotopes, distributions in surface, subsurface contaminated soil have been determined; volumes of contaminated soil with NORM that need treatment as radioactive wastes, according to the ENRRA criteria for clean-up and disposal.

Other two important wastes observed in the Egyptian oil fields are the contaminated equipment and produced water. Contaminated equipment and tubulars are stored in NORM yards of each oil field until they are decontaminated and cleaned; controlled areas were defined in each oil field and inspected periodically by the regulatory body. Additionally, produced water is usually separated from oil and disposed-off by some means such as down an injection well or disposal well.

Conclusion

The abrasive blasting cleaning facility and the dry decontamination methods developed have proven compliance with regulatory requirements for the clearance of decontaminated oil field equipment, by means of accurate and effective field measurements. It turned out to be appropriate methods of very low volume waste with almost zero secondary waste- almost 95% lower waste volume. Moreover, it presented cost-effective decontamination method that may enable E&P companies to maximizing the benefits of stockpiled assets by decontamination for the unrestricted reuse.

External gamma radiation resulting from the deposition of TE-NORM on the flow-lines; tanks, separators, etc, were measured and analyzed for some typical production facilities in the eastern desert. The selected field was a mature asset with a broad range of water-cut, with the maturation of the field the quantity of produced water increased, and the field produced water contained enhanced concentrations of naturally-occurring radionuclides dissolved in the produced water. More than 100 measurements were taken on the surface of various equipment to measure the external gamma dose rate. The dose rates ranged from background up to 66 µSv/h. Most of the measured values were within the background values. The highest measurement of 66 µSv/h was found at a production inlet separator.

In monitoring the occupational personnel using TLDs at the processing facility, the most important factors were the dose received and working time spent during Normal activities, repairs, cleaning and disposal times. The exposure pathways were mainly external exposure to gamma radiation and internal exposure to radon and radon daughters and inhalation of contaminated dust which have been reduced by protective clothes. The highest reading for TLD of workers showed received dose of 727 µSv over 6 months period, by comparing it by the worker exposure dose limits; it is still under the area of permissible dose. With the relatively detected low-doses, NORM still requires a monitoring program, since mobilization of NORM increases with the lifetime of operations and the appearance of NORM also varies strongly between reservoirs, individual wells, installations and production conditions.

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