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AA conceived and designed the study. AA and AYS performed the experiments. AA, FA, and AYS analyzed data, wrote and revised the paper.

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## Impact of Oil Industry Pollution on Health and Livelihood: Case of Harib, Marib Governorate, Yemen

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#### Abstract:

The governorate of Marib in general and the directorate of Harib, in particular, suffer from oil pollution in its various forms, which has affected the air, water, and soil. Also, it has caused many deadly diseases such as cancers and kidney failure, as well as affected the properties of groundwater and agricultural lands. The oil companies in these places have not taken any steps of mitigation harming the environment and humans or stop disposing of their hazardous waste directly into the soil and releasing toxic gases into the air. Added to this, the weak role of the government and the absence of control and accountability of these companies. This indicates that the citizens did not receive any compensation or attention for the damage that they have suffered. The current research is based on the fieldwork which was taken place in the earlier period of 2015 through the sampling of soil from contaminated sites in different areas around the oil fields in the province. In addition to the analyses of their components, a field survey was conducted in the year 2020 to check the spread of various diseases and their classification; as well as the damage of agricultural land in Harib area, in Marib Governorate, as a model and to analyze the results of ongoing field surveys. The results showed the prevalence of 17 types of cancers in 64% of the samples, as well as kidney failure and respiratory diseases, which calls for urgent action and obligating companies to build hospitals and provide treatments for the victims, also remove all hazardous waste in the area and apply environmental measures in all operations within the oil fields.

## INTRODUCTION

Oil pollution is one of the most dangerous types of pollution to humans and nature. It is multifaceted pollution caused by extraction and refining, oil industries, or the explosion of oil wells or pipelines for various reasons. The resulting waste is a direct cause of environmental hazards and the spread of diseases and epidemics in the oil production areas of the world in general and in Yemen in particular (Jammoul, 2019).

Marib Governorate is an ecoregion that has a poor structure in terms of biodiversity. However, it suffers a lot from pollution by oil residues, which has dangerous consequences for both the natural environment and human health, which draws attention to most of them to treat and alleviate these threats and reduce their effects. Hence the goal of this investigation of oil pollution risks in Marib Governorate is because of its impact on nature and human life. The Harib Directorate was selected as a sample of the study to detect the sources of environmental damages and risks in the region and their impact on the natural environment and human health.

Since the local community residence lives nearby the oil and gas production fields, they are exposed to health risks associated with installations, including wells and pipeline networks, especially natural gas venting and flaring, and the resulting emissions with dangerous health effects.

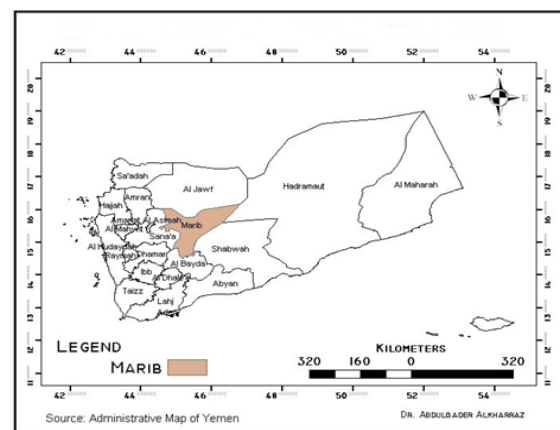
Marib Governorate is a region rich in oil fields that are close to local communities. This reality poses many dangerous threats to these societies. The most important is the burning of natural gas, accompanied by oil production and venting; as well as the deliberate burial of a lot of hazardous oil industry waste without any treatment. It is pointed out that the concerned authorities and oil companies have not provided any proper solutions to these threats, even though people have presented this to the public health department, companies and authorities. This study, therefore, addressed the assessment of oil pollution and the environmental and health

risks it poses to the population of the region in light of the indicative values provided by international bodies and organizations.

As for the research methodology, soil samples were taken from contaminated sites during fieldwork in 2015. The field survey was conducted in 2020 to monitor the spread of various diseases and classifying them, which had spread to different areas around the province's oil fields. In addition to a survey of the status of agricultural land that was conducted by select three samples in Wadi Harib, and adopted the method of a group interview with some farmers for each sample, and analyze the results of these field surveys.

## INTRODUCING MARIB GOVERNORATE

Marib Governorate is located northeast of the capital Sana'a and is about 173 kilometers from the capital Sana'a. Its area is about 17,405 square kilometers divided into 14 directorates; the largest one is the Marib Directorate. It is the center of the governorate. Its borders are Al-Jawf governorate to the north, Shabwa and Al-Baydha governorates to the south, Hadramawt and Shabwa governorates to the east, and Sanaa governorate to the west, Figure 1 shows location of Marib Governorate.



**Fig. 1.** Location of Marib Governorate in Yemen.

According to the 2004 census, its total population is 238,522, with a growth rate 2.72% of the total population of the republic distributed among all its directorates, Marib ranks first with 16.6%, while 14.1% comes from Harib (Central

Bureau of Statistics 2004) on the border of Shabwa governorate and settle near oil production sites. But today, as a result of the conditions of war and displacement, more than two million displaced people live in the governorate, according to the Executive Unit for Refugee Affairs in Yemen, which means that the governorate currently includes 10% of the population of Yemen.

### Population activities

Agriculture is the main activity of the governorate's population, ranking the third among the republic's governorates in crops production (7.6%) of the total after Hodeidah and Sana'a. The most important crops are fruits, grains, and vegetables (Ministry of Agriculture and Irrigation 2011). The most important cities of the Marib Governorate are Marib City and Harib. It is the first governorate in Yemen where oil was discovered and began its production in 1986.

### Terrain

The governorate has a unique topographic diversity that distinguishes it from other governorates and can be explained as follows:

**First: Mountain areas:** The western part of the province is predominantly mountainous, with many medium-altitude mountain ridges, some of which are steep, and the most famous mountains are the Mountains of Hellan, Shaab, Al-Wathban, Mardah, Al-Arif Mountains, and Jabal Murad.

**Second: Plains and desert areas:** Most of the governorate area on the eastern side is plain and desert. These parts make up more than half of the areas of the governorate. They are located in the Marib Directorate. They are part of a large desert that extends north towards Al-Jawf Governorate, east towards Al-Abr District, Hadramout Governorate, and south towards the northern parts of Shabwa Governorate (National Information Center, 2021a).

### Valleys

There are many valleys in the governorate, the most important of which are Wadi Dhanah in

Marib directorate and Wadi Harib in Harib directorate.

### Climate

The climate in the governorate varies according to the diversity of terrain. The mountainous areas and highlands that make up the western half of the governorate predominate, with a mild climate with a tendency to cool summer and cold winter. While the lowland and plain areas have a hot summer, mild in winter, however, the desert areas prevail in a dry subtropical climate that is hot in summer, cold dry in winter (National Information Center, 2021b).

The wind movement in the eastern part of the governorate is with prevailing direction to the northeast. Marib Governorate is one of the governorates that suffer from drought in which is a lack of rainfalls. This indicates that there is no season for rain growth in the region, so the cultivation of crops depends on irrigation from underground wells. However, the governorate experiences many effects of climate change coming from the heights of the mountains in the governorates of Dhamar and Sana'a, where Marib has experienced many floods during the last period (Al-Khurasani, 2005). The last one was in September 2020, and caused erosion for a lot of agricultural lands on the banks of the valleys, with negative impacts on public and private properties

### Biodiversity

Marib Governorate has diverse vegetation, although it is less dense in type and quantity from region to region depending on the nature of the surface and the prevailing climate. Such as trees, grasses, and plants that grow in rainy seasons, with many species of wild animals and birds found frequent in the western parts, and dense areas of trees and near valleys, especially aquatic ones (National Information Center, 2021a).

### OIL POLLUTION AND ITS RISKS TO HUMAN HEALTH

Oil exploration and production in Yemen began in 1985 in the Safer fields. Then the

environmental disaster of oil pollution began to emerge early before the outbreak of the war in 2015, as a result of the oil companies not operating according to the proper environmental measures and burying many chemicals in the soil, as well as deliberate burning of gas combined with oil, Hunt Company was burning large quantities of oil, with the Yemen Gas Company unable to set up proper local gas stations (Yemeni Parliamentarians Organization Against Corruption, 2014).

In addition to the malpractices that Hunt has carried out since the beginning of oil production and then continued by Safer until now, the hazardous waste generated from the oil industry has not been treated buried and mixed directly with the soil in different areas of the governorate (Figures 2 and 3).



**Fig. 2.** Open disposal of dangerous oil residues outside the Site of the Safer Field, 2020.



**Fig. 3.** Disposal of dangerous oil residues outside the site of the Safer field and mixing it with soil, 2020.

As well as the long-term drilling waste is dropped in the pits without any safety or treatment. It is left to evaporate toxic gases, and moved to areas of communities, and leaks the rest to the soil, then to groundwater. These

practices are proper in all oil companies in Yemen, which have been left unkempt or accountable to government agencies. This has been observed and recorded notably in oil areas between Marib and Shabwah at the Janah Hunt and Safar sites. Figure 4 shows disposal of dangerous residues without any treatment at Janah Hunt Company in 2015, and Figure 5 shows soil sampling at different locations between Shabwa and Marib in 2015.



**Fig. 4.** Disposal of dangerous oil residues without any treatment to the soil at Janah Hunt Company, 2015.



**Fig. 5.** Soil sampling from different locations between Shabwa and Marib in 2015.

This phenomenon has added a new problem to Yemen's environment, which already suffers from successive environmental problems the damage of burning and leaking the crude oil from pipes and its effect on the respiratory system of rising gases described as highly toxic. In addition to its impact on the surface, groundwater, soil, air. It causes severe environmental, economic and social damage, and the combustion of crude oil has a dangerous impact on neighboring areas.

At an earlier stage, we took soil samples of the burial and disposal of this waste from different sites with different depths. Where laboratory analyses showed that the contamination is so high with volatile petroleum hydrocarbons, as well as dangerous toxic minerals that cause cancer such as lead and chromium. Table (1) shows analysis results of the samples that have

been collected in 2015 from sites between Marib and Shabwa governorates 35 km from Harib. Figure 6 shows Oil Companies and Hazard waste sites in Marib. The rates of these elements were twice as high as those allowed internationally, whether for volatile oil hydrocarbons or even for toxic mineral elements.

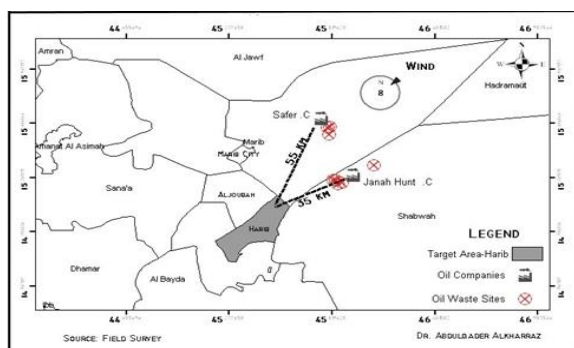
**Table 1.** Results of soil sample analysis between Marib and Shabwa provinces, 35 km away from Harib area in 2015.

| 16/2/15            | Analysis Description              |       |     | Coordinates                      |                                  |                                  |                                  |                                  |
|--------------------|-----------------------------------|-------|-----|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
|                    |                                   |       |     | N:<br>15.34370<br>E:<br>46.05973 | N:<br>15.21942<br>E:<br>45.85726 | N:<br>15.22655<br>E:<br>45.87236 | N:<br>15.24896<br>E:<br>45.83111 | N:<br>15.24487<br>E:<br>45.83236 |
| Method Reference   |                                   | Units | LOR | 1                                | 2                                | 3                                | 4                                | 5                                |
| USEPA5030B,8260B   | Total Petroleum Hydrocarbon (TPH) |       |     |                                  |                                  |                                  |                                  |                                  |
| USEPA 5030B, 8260B | C6-C9 fraction                    | mg/kg | 5   | <5                               | 121                              | <5                               | 5                                | 10                               |
| USEPA 3570C, 8015B | C10-C14 fraction                  | mg/kg | 50  | 1970                             | 19400                            | 102                              | 550                              | 1500                             |
| USEPA 3570C, 8015B | C15-C28 fraction                  | mg/kg | 100 | 10900                            | 100000                           | 754                              | 8600                             | 24800                            |
| USEPA 3570C, 8015B | C29-C36 fraction                  | mg/kg | 100 | 321                              | 3690                             | <100                             | 2700                             | 1040                             |
|                    | Heavy metals                      |       |     |                                  |                                  |                                  |                                  |                                  |
| Oven Dry           | Moisture @ 103 °C                 | %     | 0.1 | 1.1                              | 6.2                              | 0.7                              | 0.8                              | 5.8                              |
| APHA 5520 E        | Oil & Grease                      | mg/kg | 10  | 16300                            | 150000                           | 1630                             | 23800                            | 29800                            |
| USEPA 3050B, 6010B | Zinc                              | mg/kg | 1   | 22                               | 16                               | 17                               | 26                               | 32                               |
| USEPA 3050B, 6010B | Arsenic                           | mg/kg | 1   | <1                               | <1                               | <1                               | <1                               | <1                               |
| USEPA 3050B, 6010B | Beryllium                         | mg/kg | 1   | <1                               | <1                               | <1                               | <1                               | <1                               |
| USEPA 3050B, 6010B | Cadmium                           | mg/kg | 1   | <1                               | <1                               | <1                               | <1                               | <1                               |
| USEPA 3050B, 6010B | Chromium                          | mg/kg | 1   | 9                                | 15                               | 11                               | 6                                | 9                                |
| USEPA 3050B, 6010B | Copper                            | mg/kg | 1   | 6                                | 9                                | 5                                | 7                                | 6                                |
| USEPA 3050B, 6010B | Nickel                            | mg/kg | 1   | 13                               | 12                               | 14                               | 8                                | 12                               |
| USEPA 3050B, 6010B | Lead                              | mg/kg | 1   | 120                              | 3                                | 3                                | 17                               | 10                               |

Samples were analyzed at ALS Laboratories in Malaysia, Source: ( Al-Kharraz, 2015).

The high population density makes the population more vulnerable to the risks of environmental pollution, which make dangerous effects on humans and leads to severe damage (Al-Jandil and Ghaidan, 2009). However, this was proven through the field survey and the distribution of the questionnaire to a random sample number (51 individuals) in the region of Harib in September 2020; (90.2) of target patients and those who were affected by pollution, found that the major source of environmental and health damage and risks in

the region is the oil pollutants, and (2%) of the sample found the pollution source is the gases released from burning waste, while (7%) of the sample did not answer due to they did not know the causes of damage to the environment nor the diseases that they suffer. The pollution prevailing in the region is soil pollution by (74.5%), followed by (11.8%) is air pollution (Al-Kharraz, 2020). We have addressed some of these health damages in the following:



**Fig. 6.** Oil Companies and Hazardous waste sites in Marib.

**Health Risks**

Humans are exposed to a range of pollutants from human activities, whether it is gaseous, liquid, or solid, and all substances that can cause harmful effects are referred to as health or toxic effects, whether direct or indirect. Some chemical pollutants lead to severe adverse effects shortly after exposure, while the other of them lead to chronic effects, such as cancer, neurological and respiratory diseases, liver fibrosis, bloating lung pellets, or kidney diseases, and can only appear 10-20 years after exposure, the exposure varies from low amount to high amount, and exposure may be to one type of pollutant (World Health Organization, 2005). In this regard, we will discuss the results of the field survey on disease prevalence. Table (2) showed that all members of the sample have various diseases, 64.7%, from the target sample is cancer, followed by chest and respiratory diseases (17.6%), kidney disease, and kidney failure (9.8%), and (7.8%) from the sample of the study have other diseases.

**Table 2.** Percentages of diseases spread by sample study in Harib-Marib.

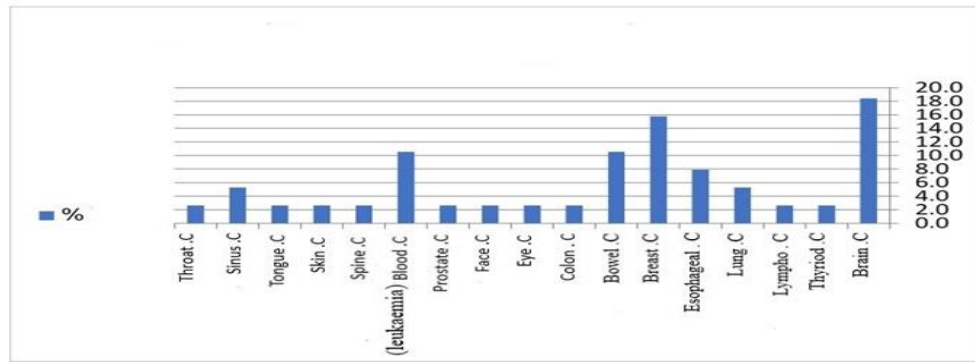
| Disease                        | Percentage % |
|--------------------------------|--------------|
| Cancer                         | 64.7         |
| Chest and respiratory diseases | 17.6         |
| Kidney diseases                | 9.8          |
| Other                          | 7.8          |
| Total                          | 100.0        |

Source: (Al-Kharraz., 2020). Field survey and samples analysis based on SPSS statistical package outputs.

**Increased incidence of cancers**

Cancer is one of the most serious medical problems, and represents the constant concern for human health in modern times; as medical science flourishes and progresses scientifically and technologically, raising scientists, doctors, and even the scientific and scientific average individual. Healthy and attracting the attention and caution of all international scientific institutions. That is because the word "cancer" has become a source of great fear for a society in which only a simple talk of the disease is raised, because of the pain and constant they are suffering. It causes to those who are infected and even to their families who live with it in difficult and dangerous moments of illness, often with the inevitable result of death (Mahmoud, 2013).

The field study showed that the highest incidence of cancer among the target sample is (64.7%) from the sample, brain and skull cancer (18.4%), breast cancer (15.8%), bowel cancer (10.5%), and leukemia (10.5%). The cancer of the esophagus (7.9%) included lung cancer (5.3%) and sinus cancer (5.3%), while the rest was distributed by 2.6% to the rest of the body, and the incidence of eye cancer was also observed from the specimen studied in the Directorate Harib (Figure 7). These results correspond to research results at the University of Texas (Williams *et al.*, 2020): A Population-Based Analysis on the spread of cancers near oil refineries, the results of which showed the prevalence of cancers such as chest, lung, lymph nodes, bladder, prostate, and colon. It is found spread 30 miles away from the sites of oil refineries or about 50 km, and this corresponds to the results of this survey conducted by all these diseases are present with other types of cancers besides the distance from the oil fields and refineries of Safer Oil Company and Janah Hunt field, which was approximately 35 to 60 km and these dangerous effects of the spread of diseases appeared.



Source: September 2020 survey results and survey sample analysis, based on statistical package outputs (spss)

Fig. 7. Distribution of cancer according to the type of infection.

Cancer cases included both males and females, and the study showed that the incidence rate among females is higher than among males as in Table 3, which confirms that the cause of the spread of this dangerous disease is oil pollution, as females are free from chewing qat (qat or khat is a tree grown in Yemen), smoking or drinking alcohol according to common habits. Scattered in the area, they are either agricultural, irrigation, or timber workers, which means that they are exposed directly to the damages of oil pollution in the area.

Table 3. Percentages of cancer patients by gender type in Harib-Marb.

| Gender | Percentage % |
|--------|--------------|
| Male   | 42.1         |
| Female | 57.9         |
| Total  | 100.0        |

Source: (Al-Kharraz., 2020). Field survey and samples analysis based on SPSS statistical package outputs.

While children did not survive the risk of contracting this disease due to their direct receipt of these pollutants, brain cancer was the highest among children, as shown in Figure 8 (Al-Kharraz, 2020).



Fig. 8. Cancer rates among children in Harib-Marib.

Chemical pollutants to which humans are exposed are among the main causes of cancer, whether direct exposure by breathing, skin, or indirect through eating and drinking and cancer can increase as a result of unusual radiation exposure, viral infection, and reduction of immunity. In addition to certain chemicals, there is no way to exclude the risk of cancer by any chemical compound to such an extent that all chemicals can be said to cause cancer to certain species of organisms and under certain exposure conditions (Briffa *et al.*, 2020).

**Effect on the respiratory and chest**

The combustion of oil and gas is accompanied by the emission of many highly toxic gases, such as hydrogen sulfide (H<sub>2</sub>S), carbon oxides, sulfur, and nitrogen, as well as the release of some toxic mineral elements such as mercury and arsenic, leading to human erosion of many

dangerous chronic respiratory diseases, the most important of which are:

- Chest infections where it leads to painful cough and finally to lung disease.
- The crisis (asthma) causes acute difficulty in breathing.
- Lung fibrosis is caused by asbestos, silica, coal, and eventually leads to lung cancer (Mohammad and Abd al-Nabi, 2017).

The incidence of thoracic and respiratory diseases in the sample was about 17.9%. Chronic disease is spread among the population as a result of exposure to gases released by the combustion of oil and gas, especially sulfur dioxide, which significantly affects the respiratory system, mucosal membranes, and eyes, as well as hydrogen gas affecting the hippocampus. High concentrations lead to loss of the sense of smell. Nitrogen oxides cause many health effects on the respiratory system and mucosa and lead to pneumonia and asthma (Environmental Terrorism, 2014).

This problem has been exacerbated in the study area by the trend of wind traffic, where the trend is north-eastern. These winds transport contaminants from the oil sites directly to search area (Figure 9), and the mountains and hills around the residential areas form a corridor (Windy, 2021). The competent monitoring of air pollutants and wind traffic increases the concentration of air pollutants in the Harib area from 10 p.m. to early morning hours.



**Fig. 9.** Wind Direction and Location of the Study Area of Oil Fields, source windy website.

These diseases kill many people prematurely, and cause serious health problems, threaten human and economic development, increase poverty rates among individuals and families and impede social and economic development (Mohammad and Abd al-Nabi, 2017). Many people fall into poverty every year, in the study area, because they have to spend and pay for the necessary health services for the treatment of diseases, which rapidly drains family resources.

### Effect on the kidneys

Chronic diseases associated with chemical contamination are difficult to detect, monitor and diagnose, until after chronic renal failure has occurred. Water pollution is mainly responsible for the widespread of chronic and dangerous infections in the region and causes permanent health risks to a large number of the population (Baroud and Maddoukh, 2016).

Water in Marib Governorate is of poor quality due to its high salinity as a result of chemical contamination of most of the underground reservoir in Marib Governorate, which causes many diseases, especially chronic kidney failure, and was the most important indicator of chemical pollution: the occurrence of kidney diseases and kidney failure (9.8%). Most of the study sample members suffer from kidney failure and their suffering increases with their constant need for dialysis between 4 and 12 times a month. In addition, it is difficult to reach the hospital as only a few of them need more than an hour to arrive at the dialysis center, while most of them spend several hours, which increases their suffering. Some had kidney transplants, including a donor from some relatives, and others in exchange for a financial allowance. All patients in the study sample did not receive any support or assistance from the companies that caused their suffering, organizations, local authorities, and others.

Despite the high chemical contamination of groundwater in the wells of Harib Directorate, the survey has shown that many patients with chronic kidney failure depend on well water for drinking before they become affected, (Al-



Kharraz, 2020) particularly if chemical contamination exceeds the international standards of chemical pollutants, which causes many dangerous diseases, the most important of which are kidney diseases leading to the chronic kidney failure (Baroud and Maddoukh, 2016).

### **Other health effects**

The study showed the prevalence of many diseases, such as liver diseases, among Harib's citizens, which accounted for about 2% of the study sample. That is due to the high proportion of radioactive materials, carbon halogens, and arsenic caused by the combustion of high measures of gas into the atmosphere, as well as the incidence of genital diseases, as well as skin and eye diseases, and other diseases that spread to varying proportions among the population of the region, as a result of direct or indirect exposure to oil pollutants from oil and gas combustion in the safer company area near the region.

The current situation of the injured shows that 66.7% of them are alive, and they suffer from diseases and their condition is bad, with the continuation of treatment at their own expense.

While the death rate was (33.3%) of the sample, their cases were very bad to the point of death due to diseases. Knowing that the medical expenses for all the injured are at their own expense and none of them received any support from any party. This reflects the size of the environmental risk by exposure to oil pollutants in the region, which appeared mostly intensified during the period (2000 - 2020).

### **Destruction of livelihoods**

More than 60% of the region's population depends on natural resources for their livelihoods. However, pollution from the oil industry destroys the vital resource on which they depend, causing extensive damage to agricultural land, by oil spills, and dumping of liquid waste, as solid, as well as gas waste.

Through the results of the field survey and the group interview for three sites in Wadi Harib, which differ in their distance from the oil

production sites, it was found that the average agricultural land affected by pollution (70%) of the total cultivated area in the region, where the pollution has led to the destruction of most agricultural land as happened in the areas of Abu Tahaif and Al-Aqeel (35 km from Janah Hunt and 55 km from Safer) below Wadi Harib near the area of oilfields, and the villages of Al-Aweidan and Al-Ashraf (60 km) in the center of the valley. Pollution has led to a marked deterioration in productivity and loss of fertility, as observed in the Al-Ayn region (65 km) of the source of pollution.

This situation has harmed the livelihoods of the population; as the results from the survey of agricultural land show that the amount of agricultural production was reduced to (90%) in the Abu Taif and Al-Aqeel regions, and (70%) in the villages of Al-Awaydan and Al-Ashraf, and 60-65% in Al-Ayn village. All crops are (citrus, grain, vegetables, fruits, feed).

For example, wheat production decreased by 30 to 50%, while citrus production decreased by 70 to 90% after the establishment of oily industries in the region, and most crops production such as maize and wheat were stopped. The sesame production stopped completely. The land where crops grow has been overwhelmed by foul vegetation and some species of grasses, which means the land has ceased production. Also, the number of livestock in the region reduced to about 90% at the Directorate level.

Oil pollution caused many diseases for animals, the most important of which are: (tremor, epilepsy, rickets, suffocation to death) (Al-Kharraz, 2020).

One of the long-term effects is damage to soil fertility and agricultural productivity, which in some cases can last for decades, and in many cases, the long-term effects of oil spills on soil have undermined the family's only source of livelihood (Amnesty International, 2009). This led to the migration of some families to their agricultural lands after the wells dried up and the trees died, as in Figures 10 to 13.



Fig. 10. Degradation of orange farmlands in Wadi Harib, 2020.



Fig. 13. Degradation of orange farmlands in Wadi Harib, 2020.



Fig. 11. Degradation of grain cultivation in Wadi Harib, 2020.



Fig. 12. Migration from homes and farms due to drought in Wadi Harib, 2020.

Figure 14 also showed a comparison of satellite images of Google Earth Abu-Taif and Al Aqeel down Wadi Harib for the period between 2003 and 2019 which the degradation of agricultural land in the region is evident.

The previous images that have been taken through Google Earth show the level of the deterioration of agricultural land in the Area of Abu-Tahaif and Al Aqeel, down the valley, between 2003 and 2019. The degraded agricultural land expanded in 2019, threatening the loss and desertification of this land and thus damaging the livelihood and life of the population.

The results of the survey confirm the damage to the livelihood of the population caused by oil pollution, as well as the damage to many crops by air pollution, the extent of which has not yet been determined.

In addition, the decline in the value of the agricultural crop results in various types of damage to the leaves of the plant, the low growth of the plant, or the low volume and production of fruits (Abboud, 2013). The arrival of hydrocarbons in saturated soils in the form of raw oil or natural gas affects plant cells directly, alters soil composition and cohesion, and reduces organic content (Environmental Terrorism, 2014).

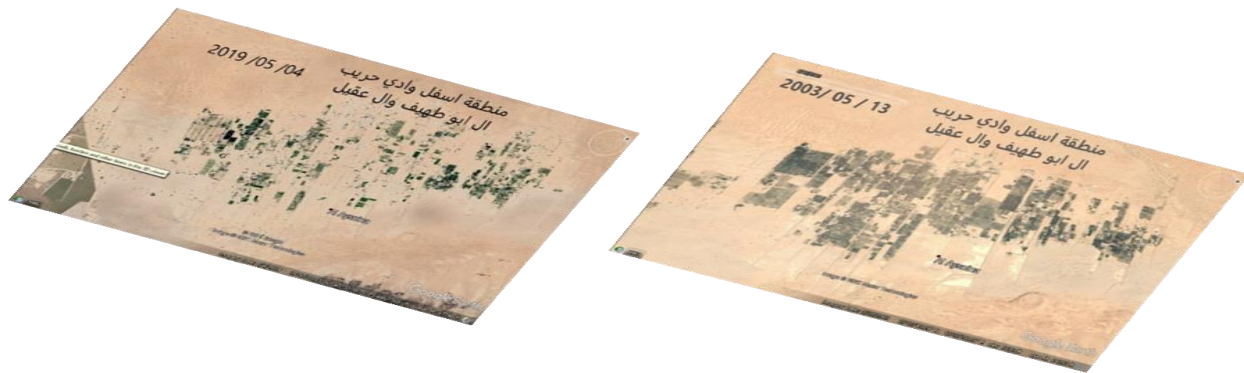


Fig. 14. Comparison between 2003 and 2019 of agriculture lands degradation down Wdi Harib.

Furthermore, the significant contamination of groundwater in the remaining wells, most of them have dried up with the continued decline in the water levels (30 m) in 1990 to (120 m) in 2020, due to the continued overexploitation by oil companies to meet their water needs in the extraction and production process. Disposal of water associated with the extraction and other effluents at different and random locations as in Figure 15, as a model that combines the extent of damage caused by the use of deep drilling to dispose of liquid oil waste at oil production sites between 2013 and 2016 and the lack of attention to the risks to the environment and humans.

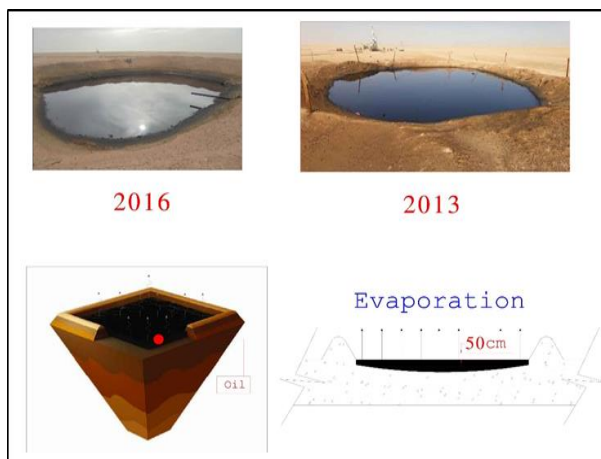


Fig. 15. Comparison of the status of discharged hazardous waste from 2013 till 2016. Source: (Al-Kharraz, 2016).

## CONCLUSION

The gas problem in Yemen began in Marib in block 18, where it appeared accompanying the oil explorer Hunt was burning large quantities of it in the light of the inability of the Yemeni gas company to set up enough plants to produce domestic gas, which contributed greatly to the emergence of the risks of pollution and the emergence of the gas and oil crisis in Yemen.

The prevalence of cancers of various kinds in the study area was 66% of the sample, and there were exotic types of cancers, including eye cancer.

The major source of environmental and health damage and risk in the region is petroleum pollutants (air pollution, burial of hazardous chemical residues, and depletion of groundwater in oil industries).

People in the region depend on the natural environment for their livelihoods, but pollution from the oil industry destroys their livelihood resources on which they depend and causes significant damage.

The absence of the role of relevant government agencies, the lack of support for those affected, the lack of oversight or accountability of companies, and lacks the concern of researchers to monitor oil pollution damage in the region.

## RECOMMENDATIONS

Obliging companies to adopt proper methods for the disposal of contaminated waste and not to dump oil waste directly into the soil and surrounding production sites. Remove and treat all residues buried in the soil.

Compensating those affected in terms of both health and agriculture- It should be fair compensation that takes the material and psychological aspects, negligence, and deliberate landfill by oil companies in the area.

Concerted efforts to combat pollution and reduce its spread in the region.

Establishing specialized hospitals and health centers for disease control in the region.

Activate the role of researchers and those interested in studying and monitoring oil pollution and resulting environmental and health problems in the region. Work to implement a comprehensive field survey of all areas of the governorate of Marib where cancers are prevalent.

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## CONFLICT OF INTEREST

There is no conflict of interest.

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