



YEMEN ENVIRONMENTAL BULLETIN: OIL EXTRACTION INDUSTRIES' IMPACTS ON HEALTH, LIVELIHOODS AND THE ENVIRONMENT IN HADRAMAWT

By:

Yasmeen al-Eryani

December 16, 2020

YEMEN ENVIRONMENTAL BULLETIN: OIL EXTRACTION INDUSTRIES' IMPACTS ON HEALTH, LIVELIHOODS AND THE ENVIRONMENT IN HADRAMAWT

By:
Yasmeen al-Eryani

December 16, 2020

COVER PHOTO: A farmer tends his crop in an oil concession area of Sayoun, Hadramawt, December 4, 2020. // Sana'a Center Photo by Mohammed Hayyan



The Sana'a Center for Strategic Studies is an independent think-tank that seeks to foster change through knowledge production with a focus on Yemen and the surrounding region. The Center's publications and programs, offered in both Arabic and English, cover political, social, economic and security related developments, aiming to impact policy locally, regionally, and internationally.

OxfordResearchGroup
building bridges for global security

Oxford Research Group (ORG) is an independent organization that has been influential for nearly four decades in pioneering new, more strategic approaches to security and peacebuilding. Founded in 1982, ORG continues to pursue cutting-edge research and advocacy in the United Kingdom and abroad while managing innovative peacebuilding projects in several Middle Eastern countries.



TABLE OF CONTENTS

Executive Summary	4
Introduction	8
Limited Available Research and Suppression of Information	8
Background on Hadramawt	10
Activities that May Result in Contamination	14
Produced Water	14
Open-air Holding Ponds	19
Injecting Produced Water into the Ground	23
Waste and Leftover Material from Exploration Activities	25
Unmaintained Wells	27
Air Pollution	28
Health Concerns	29
Political and Social Contexts	30
Legal Context and the Authorities Responsible for Safeguarding the Environment	32
The Role of the Local Authority	34
The Community's Limited Role	35
International Arbitration by the Government of Yemen	36
Looking Ahead	37
Recommendations	38

EXECUTIVE SUMMARY

This policy brief on the environmental impact of the oil extraction industries in Hadramawt explores what seems to be a well-known secret among residents living near oilfield concession blocks and people from the industry: that oil exploration and production activities in the governorate may be deviating from sound environmental standards and could be posing a serious risk to the environment and public health. When it comes to environmental and health impacts, there are no definitive studies that document and analyze incidents of pollution due to error or negligence in oil exploration and production activities beyond occasional unpublished environmental impact assessments (EIAs) retained by the Ministry of Oil and Minerals or the oil companies. Combined with the lack of open government records on operations and contractual arrangements with companies and their subsidiaries, accessible oil sector information is severely limited.

What is known, however, is that concession blocks are located in the plateau area, which is the watershed that feeds the populated agricultural and grazing valleys (wadis) of Hadramawt. When it rains, waste that includes large quantities of high salinity produced water and other chemicals used in oil production are washed away from oilfields and into tributary valleys, according to key informants in the oil industry, the local authority and civil society. These rainwaters replenish groundwater and feed into the main wadis of Hadramawt, risking the contamination of water resources, soil and vegetation. Air pollution through unfiltered gas flaring is also prevalent around productive oil fields.

The data also reveal that residents have been sending complaint letters to the local authority and the Ministry of Oil and Minerals expressing concern about the impact of these industries on their crops, livestock and health for the past two decades. While some of these complaints led to field visits and official inquiries, there is no indication that sufficient action was taken to prevent future incidents of pollution and mitigate the risks of oil production and exploration on the population and livelihoods. On the other hand, reports from the National Center of Public Health Laboratories and the National Oncology Center in Hadramawt point to a noticeable increase over the years in cancer cases among residents of Wadi Hadramawt, the inland area of the governorate surrounded by oil fields. While the cause of this serious health concern cannot be established without proper studies that aim to understand the underlying factors, residents and

health professionals suspect it is linked to oil industry pollutants.

The oil industry makes up the main source of government revenue, and authority over the sector is extremely centralized and prone to political corruption and patronage networks. Oilfield areas are highly securitized and access to them is restricted. Some government agencies responsible for environmental inspections report that they are not granted access to the oilfields and do not duly receive copies of EIA reports from the environmental division under the Ministry of Oil and Minerals, while insiders from the oil companies report serious deviations from international environmental standards, with operations occurring under practically no government monitoring or oversight.

Based on the initial findings of the brief, a list of actionable short- to mid-term policy recommendations are presented. These include:

- filling the knowledge gaps through initiating comprehensive studies on the environmental and health impacts of the oil extraction industry's activities;
- assuming a greater role by the local authority in operations conducted in the governorate, including reviewing contractual arrangements with oil companies and participating in monitoring and oversight of oil production and exploration activities;
- requiring a thorough EIA enforced by the government prior to the commencement of any oil operations and requiring regular EIAs throughout oil operations;
- ensuring EIAs are shared with all the relevant bodies and a mechanism to follow through with the recommendations is established in consultation with the Environment Protection Authority and the local authority;
- establishing a technical office in Hadramawt responsible for conducting appropriate studies and inspection visits to the oilfields;
- engaging civil society at the district and governorate levels to improve awareness within communities of residents' rights, how oil extraction industry-related contamination can affect their health, crops and livestock, and how they can mobilize and effectively demand action from the responsible authorities; and
- deploying geographic information system (GIS) technology for the environmental monitoring of oil fields — such as leaking pipes and open-air ponds holding produced water.

LIST OF ABBREVIATIONS

CPF	Central Processing Facility
EIA	environmental impact assessment
EPA	Environment Protection Authority
ESCWA	United Nations Economic and Social Commission for Western Asia
GIS	geographic information system
NCPHL	National Center of Public Health Laboratories
NGO	non-governmental organization
NORM	naturally occurring radioactive material
PEPA	Petroleum Exploration and Production Authority
PSA	production sharing agreement
BTEX	benzene, toluene, ethylbenzene and xylenes

LIST OF ILLUSTRATIONS

Figure 1: Main sedimentary basins in Yemen

Figure 2: Hadramawt districts and concession blocks

Figure 3: Satellite image of apparent holding ponds, Block 51, Hadramawt

Figure 4: Zoom in on one holding pond, Block 51, Hadramawt

Figure 5: Stratigraphic section of Masila Basin

INTRODUCTION

Limited Available Research and Suppression of Information

There is no conclusive data on the environmental and health impact of oil extraction industries in Yemen, and comprehensive studies are practically nonexistent. This policy brief relies on a desk review of documents, reports and white papers that discuss the issue of pollution associated with crude oil production and exploration activities in Hadramawt. To complement the lack of data, 17 interviews with key informants were conducted between August and October 2020. These included:

- a former minister of oil and minerals;
- a former minister of water and environment;
- the acting chairman of the Environment Protection Authority (EPA);
- the director general of the Hadramawt office of the EPA;
- an official in the governor's office;
- four petroleum engineers (three of whom have worked on the Masila basin oil fields);
- a member of parliament for the Mukalla district;
- the director general of the National Center of Public Health Laboratories (NCPHL) in Hadramawt;
- two heads of Hadrami charity associations, including an association that supports cancer patients and keeps a register of cancer incidents in Hadramawt;
- a professor of agriculture in Sana'a University who has been writing on the topic since the 1990s;
- two Hadrami university researchers who attempted to gather and test samples from concession areas but were met with a series of obstacles that led them to abandon their research; and
- a former environmental consultant for oil companies who conducted a number of environmental impact assessments (EIAs) in Yemen.

The data at hand clearly indicate that the oil sector in Yemen is a redline for researchers and anyone who attempts to investigate its operations. Initially, several informants were reluctant to discuss the matter for fear of retaliation; some only agreed to interviews under condition of confidentiality. That being said, the accounts of pollution and damage to livelihoods overlapped, with a number of informants also noting that residents have been for years sending official letters of complaint to various ministries and local officials. Some of these complaints made it to the top leadership in the country, and committees of various compositions were sent to the field sites to gather data and write up reports. In some cases, the findings of these reports were discussed in meetings at the governorate level or in parliament, but most seem to have been shelved. According to a consultant who carried out EIAs for oil companies, these assessments were sent to the environmental division in the Petroleum Exploration and Production Authority (PEPA), which is under the Ministry of Oil and Minerals. The environmental division in PEPA is mandated to share EIA findings with the Environment Protection Authority (EPA), which is under the Ministry of Water and Environment, however this rarely happened during the consultant's work. On occasion, the consultant said he took the initiative to share some of these reports with the EPA when he learned neither the oil companies nor PEPA had expressed any willingness to respond to their findings on environmental risks.⁽¹⁾ This reflects how the responsibility for ensuring the environmental safety of the industry is diluted among various environmental bodies spread across multiple ministries while the local authority is sidelined.

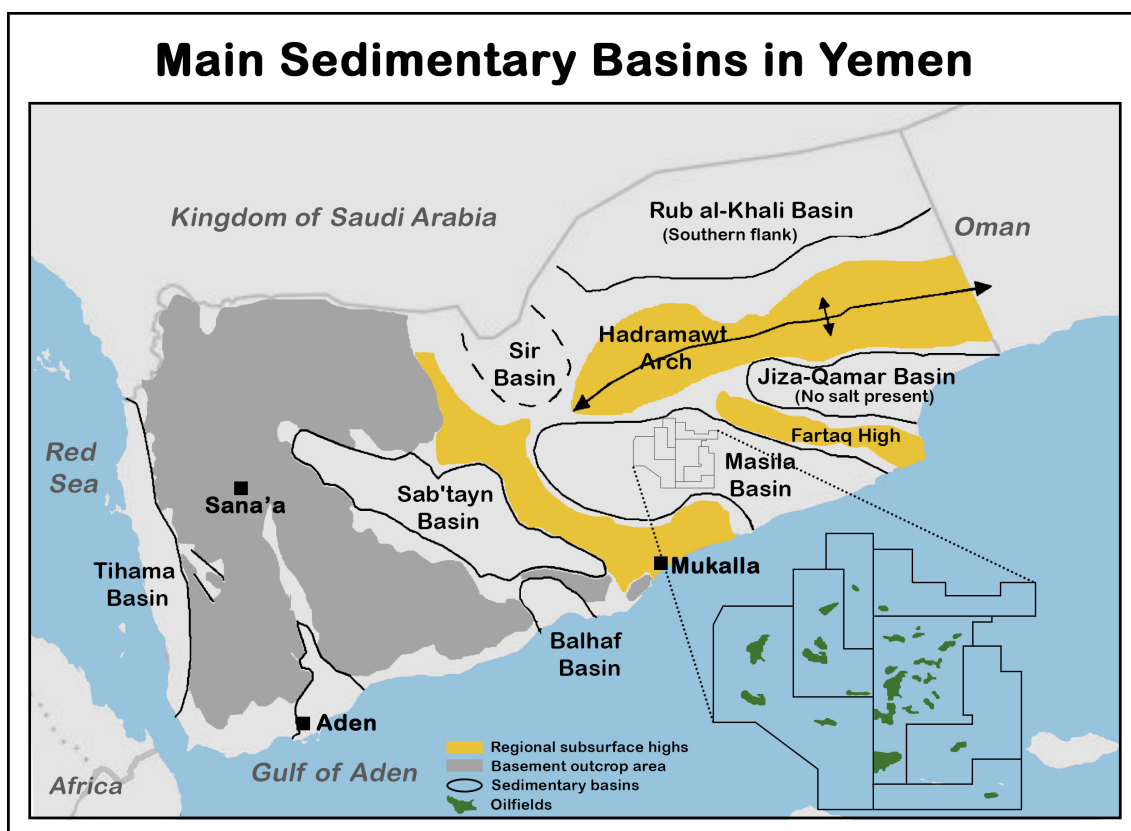
This policy brief will present the kind of activities that may be causing contamination of soil, water and air in the concession areas, provide some context to the problem and conclude with short- to medium-term recommendations for policy action.

1) Sana'a Center interview with an environmental impact consultant who carried out EIAs in Yemen from 2002-2010, October 9, 2020.

Background on Hadramawt

The governorate of Hadramawt sits on one of the two main petroleum-bearing basins in Yemen, the Masila basin (also known as Sayoun-Masila basin or Masila-Jeza basin), which covers a surface area of about 25,000 square kilometers⁽²⁾ and contains 80 percent of Yemen's known oil reserves.⁽³⁾ To the west, separated by the Jahi-Mukalla High, is the Sab'tayn basin (also known as the Marib-Shabwa basin or the Marib-Al-Jawf/Shabwa basin). The petroleum basins are divided into concession blocks, defined areas granted by the Yemeni government to oil companies on a contractual basis through what are known as production sharing agreements (PSAs).

Figure 1:



Source: Mohammed Hail Hakimi, Wan Hasiyah Abdullah, and Mohamed Ragab Shalaby, 2016.⁽⁴⁾

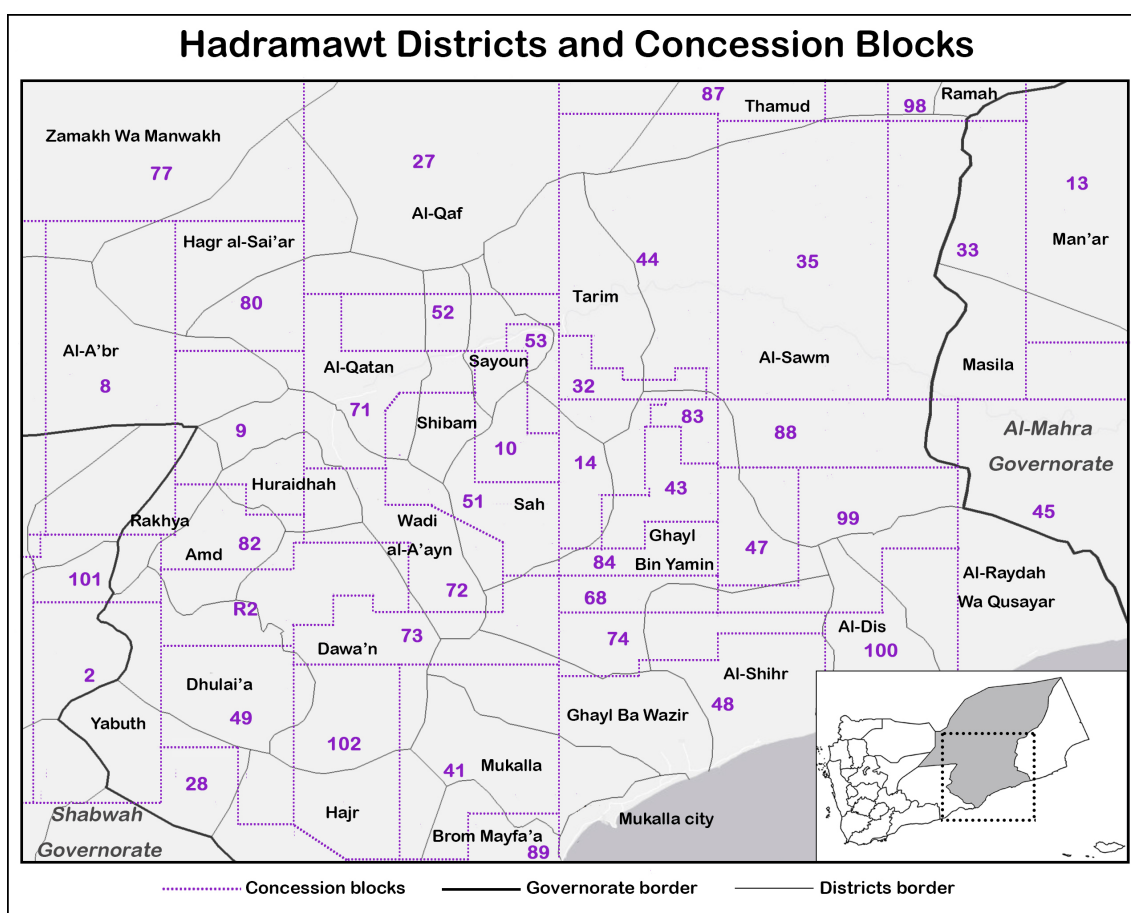
2) Richard Harris, Mark Cooper, Ian Shook, "Focusing Oil and Gas Exploration in Eastern Yemen by Using Satellite Images and Elevation Data along," *RECORDER*, The Canadian Society of Exploration Geophysicists, Volume 28, No. 2. (Calgary, Canada), February 2003, <https://csegrecorder.com/articles/view/focusing-oil-and-gas-exploration-in-eastern-yemen-using-satellite-images>

3) "Yemen," U.S. Energy Information Administration, last updated July 6, 2017, https://www.eia.gov/international/content/analysis/countries_long/Yemen/yemen.pdf

4) Mohammed Hail Hakimi, Wan Hasiyah Abdullah, and Mohamed Ragab Shalaby, "Madbi-Biyadh/Qishn (!)

Based on PEPA's latest available record from 2012, there are 105 concession blocks in Yemen, of which 13 are categorized as oil producing, 26 as exploration blocks and 66 as open for exploration.⁵⁾ The concession blocks range in size from more than 8,000 square kilometers in Marib (Block 18) to as small as 280 square kilometers in Shabwa (Block 5).

Figure 2:



Source: PEPA

Petroleum System in the Onshore Masila Basin of the Eastern Yemen,” *Marine and Petroleum Geology* 35, no. 1, August 2012, pp. 116–127, <https://doi.org/10.1016/j.marpetgeo.2012.01.009>. Modified from Beydoun, Z.R., International Union of Geological Sciences, International Commission on Stratigraphy and Yemen Ministry of Oil and Minerals, *International Lexicon of Stratigraphy: Republic of Yemen*, (IUGS and Ministry of Oil and Mineral Resources, Republic of Yemen, 1998).

5) “Concession Map Overview,” Petroleum Exploration and Production Authority, The Republic of Yemen, last updated 2012, <http://www.pepa.com.ye/Concession/concession.htm>

In Hadramawt governorate, Block 9 has the largest surface area, with more than 2,000 square kilometers currently operated by Calvalley Petroleum (Cyprus) Ltd.⁽⁶⁾ Block 9 sits slightly to the west of other key oil producing blocks, namely Blocks 14, 10, 51 and 53, which are currently operated by PetroMasila,⁽⁷⁾ 200 to 300 kilometers northwest of the capital, Mukalla. Block 14 (1,250 square kilometers) was the first to begin producing in Hadramawt; it contained 16 oil fields including the largest, Tawila oil field.⁽⁸⁾ Block 14 is now considered a mature block and production in it has significantly dropped from its peak in 2003 when it averaged more than 200,000 bpd to 10,000 bpd in 2014.⁽⁹⁾ Most oil exports go through Ash-Shihr terminal on the Hadramawt coast. Although there are officially 13 oil-producing blocks designated by PEPA, not all are active. Yemen's oil production peaked in the early 2000s and has been in decline since. International oil companies began pulling out of Yemen as the war escalated between late 2014 and early 2015, while production in Hadramawt ceased after AQAP took control of Mukalla in April 2015.⁽¹⁰⁾ It resumed in 2016 but at a rate drastically lower than in the pre-war period.⁽¹¹⁾

Hadramawt also sits on the largest of the four main freshwater aquifers in Yemen,⁽¹²⁾ the Mukalla sandstones, which stretch beyond Yemen's borders into Saudi Arabia and Oman.⁽¹³⁾ The Mukalla aquifer sits on a ground formation above Al Qishn limestone formations, the main oil reservoir, separated by another layer of sandstones known as Harshiyat (See figure 5).

Hadramawt is the largest governorate in Yemen, with a surface area of more than 190,000 square kilometers, about 35 percent of the total surface area of Yemen.

6) "Operations: Current Production," Calvalley Petroleum (Cyprus) Ltd., accessed August 27, 2020, <https://www.calvalleypetroleum.com/new-current-production/>

7) "Assets and Facilities," PetroMasila, accessed August 27, 2020, <https://petromasila.com/assets-facilities/>

8) Adel Al-Johi, Elkhedr Ibrahim, Hussain J. Al Faifi, Mostafa M. Kinawy, Nassir S. Al Arifi, Aref Lashin, "Investigating deep geological reservoirs using seismic reflection and well logs, Tawila oil field, Yemen: Implications for structural setting and reservoir properties," *Journal of Petroleum Science and Engineering*, Volume 176. 2019. pp. 1018-1040, 2019, DOI: 10.1016/j.petrol.2019.02.020

9) "Yemen Monthly Economic Update," World Bank, December 2019, <http://pubdocs.worldbank.org/en/360391580209593452/Yemen-Update-Dec-2019.pdf>

10) Peter Salisbury, "Yemen: National Chaos, Local Order," Chatham House, December 2017, <https://www.chathamhouse.org/sites/default/files/publications/research/2017-12-20-yemen-national-chaos-local-order-salisbury2.pdf>

11) "Local Visions for Peace in Hadramawt," Sana'a Center for Strategic Studies, August 1, 2019, <https://sanaacenter.org/publications/main-publications/7893>

12) Mukalla aquifer stores about 10 million cubic meters of freshwater, the other three main aquifers in Yemen are the Tihama Quaternary aquifer (250,000 cubic meters of stored freshwater), the Southern Coastal Plains (70,000 cubic meters of stored freshwater), and the Highland plains (50,000 cubic meters of stored freshwater). See van der Gun, Jac & Ahmed, Abdul, "The Water Resources of Yemen. A summary and digest of available information," 1995, DOI: 10.13140/RG.2.1.2616.1362

13) "Groundwater Management in Yemen: Draft Synthesis Report," Food and Agriculture Organization of the United Nations, Rome, 2009, http://www.groundwatergovernance.org/fileadmin/user_upload/groundwatergovernance/docs/Country_studies/Yemen_Synthesis_Report_Final_Groundwater_Management.pdf

It is divided into 28 administrative districts and is sparsely populated, making up a little over 5 percent of the Yemeni population.⁽¹⁴⁾

Despite its size, abundance of natural resources and relatively small population, Hadramawt only fares slightly better than other Yemeni governorates in terms of poverty indicators. A 2018 report by the United Nations Economic and Social Commission for Western Asia (ESCWA) that measures multidimensional poverty – meaning access to health, education and safe drinking water – found that more than 56 percent of the population in Hadramawt suffers from multidimensional poverty, including close to 16 percent suffering from acute multidimensional poverty.⁽¹⁵⁾ There is a sense of indignation among Hadrami interlocutors that not only is oil wealth not fairly reinvested into their governorate but also that oil companies are damaging Hadramawt's environment, turning this natural resource into “a curse” as expressed by the Hadrami parliamentarian, Muhsen Ba Surrah.⁽¹⁶⁾ Notably, Hadramis have been petitioning the central government since at least 2007 to retain 20 percent of oil revenue generated in the governorate for local services;⁽¹⁷⁾ it was only after President Ali Abdullah Saleh's fall from power in 2012 significantly weakened the central government that Hadramawt successfully secured this arrangement.⁽¹⁸⁾

Flash floods are a common occurrence and are increasing in frequency and severity with climate change.⁽¹⁹⁾ This means that surface pollution from crude oil production and its byproducts can be carried long distances, affecting the environment and well-being of residents in areas many kilometers away from the oilfields. Moreover, the two main income-generating activities in the governorate are agriculture and animal husbandry, with about 3 million head of livestock present in Hadramawt.⁽²⁰⁾ These activities are extremely vulnerable to soil and water contamination.

14) “A Brief Overview of Hadramawt Governorate [AR],” National Information Center, Republic of Yemen, last updated 2014, <https://yemen-nic.info/gover/hathramoot/brife/>. This record does not reflect that Socotra had been declared a governorate separate from Hadramawt in 2013.

15) “Multidimensional Poverty in Yemen,” Economic and Social Commission for Western Asia (ESCWA), Beirut. October 2018, ref: E/ESCWA/EDID/2018/WP.7

16) Sana'a Center interview with Muhsen Ba Surrah, member of parliament, August 19, 2020.

17) April Longley Alley, Abdul-Ghani al-Iryani, “Fighting Brushfires with Batons: An Analysis of the Political Crisis in South Yemen,” Middle East Institute Policy Brief, No. 7, February 2008, <https://www.mei.edu/publications/fighting-brushfires-batons-analysis-political-crisis-south-yemen>

18) Osamah Al-Rawhani, “A Strong Central State: A Prerequisite for Effective Local Governance in Yemen,” Arab-Reform Initiative, October 17, 2019, <https://www.arab-reform.net/publication/a-strong-central-state-a-prerequisite-for-effective-local-governance-in-yemen/>

19) Yasmeen Al-Eryani, “Yemen Environment Bulletin: How Weak Urban Planning, Climate Change and War are Magnifying Floods and Natural Disasters,” Sana'a Center for Strategic Studies, July 14, 2020, <https://sanaacenter.org/publications/analysis/10346>

20) “Economic Activities in Hadramawt Governorate [AR],” National Information Center, Republic of Yemen, last updated 2014, <https://yemen-nic.info/gover/hathramoot/actioneconom/>

ACTIVITIES THAT MAY RESULT IN CONTAMINATION

Without definitive studies and field research, causes and effects of pollution cannot be ascertained. However, based on what has been gathered, a number of activities repeatedly emerged from key informant interviews, reports carried out by national nongovernmental organizations (NGOs) as well as unpublished EIAs obtained by the Sana'a Center, identifying possible contributors to pollution associated with oil production. These related to:

- the dumping of produced water — a byproduct of oil extraction containing production chemicals, salts and hydrocarbon residue — directly on the soil or in open-air ponds with damaged plastic lining;
- injecting large amounts of this liquid waste into ground formations that are not sealed from freshwater aquifers instead of following the industry standard of reinjecting it into the oil reservoir;
- mismanagement and negligence in disposing of other industrial waste, such as empty barrels, metal pieces, pipes and chemicals used in exploration activities;
- negligence in maintaining wells, monitoring in-well corrosion of casings;⁽²¹⁾
- properly sealing wells that are no longer in use;
- incomplete or faulty well casings that may lead to the contamination of aquifers; and
- polluting the air through flaring of large amounts of gas.

Produced Water

Produced water is a byproduct of crude oil extraction. Water, often naturally present in the reservoir along with gas and hydrocarbons, comes out associated with oil in the extraction process. Produced water is separated from oil in a central processing facility (CPF), where oil then travels through pipes to Ash-Shihr terminal for export, while produced water is either reinjected into the reservoir using a powerful compressor or disposed of in other ways. Moreover, it is not

21) "Oilfield Glossary: casing," Schlumberger, last updated 2020, <https://www.glossary.oilfield.slb.com/en/Terms/c/casing.aspx>

uncommon to inject liquid into the reservoir during oil production to maintain the pressure of the reservoir and improve recovery rates; freshwater, brine or seawater are commonly used in the reinjection process.⁽²²⁾

Produced water is high-salinity water, sometimes exceeding the salinity of seawater by many folds.⁽²³⁾ It contains soluble and insoluble organic chemicals as well as chemicals added in the drilling and extraction process such as biocides, scale and corrosion inhibitors, and de-emulsifiers.⁽²⁴⁾ Organically occurring and added chemicals involved in extraction contain (but are not limited to) benzene, toluene, ethylbenzene and xylenes — a cocktail referred to as BTEX, known to have carcinogenic risks and that could harm the lungs, eyes, and nervous system.⁽²⁵⁾ In addition to these, produced water may contain naturally occurring radioactive material (NORM).⁽²⁶⁾

Thus, produced water is highly complex and its composition and level of salinity vary among wells⁽²⁷⁾ depending on the lifetime of the reservoir and its geologic formation.⁽²⁸⁾ Because of these variations in composition, regular localized studies are required to assess the environmental risks of produced water on soil, water and vegetation. There have been technological advances in treating and reusing produced water, but these processes are costly and there is no evidence to suggest they have been attempted in Yemen.

22) Hagström, Earl L., Christopher Lyles, Mala Pattanayek, Bridgette DeShields, and Mark P. Berkman, "Produced Water: Emerging Challenges, Risks, and Opportunities," *Environmental Claims Journal* 28 (2), 2016, pp. 122–39, doi: 10.1080/10406026.2016.1176471; Jerry Neff, Kenneth Lee, and Elisabeth M. DeBlois, "Produced Water: Overview of Composition, Fates, and Effects," *Produced Water*, (New York: Springer New York, 2011), pp. 3–54, DOI: 10.1007/978-1-4614-0046-2_1

23) Ibid.

24) Tom Whalen, "The Challenges of Reusing Produced Water," *Journal of Petroleum Technology* 64 (11), 2012, pp. 18–20, DOI: 10.2118/11112-0018-JPT

25) Eric J. Esswein, Kyla Retzer, Bradley King, Margaret Cook-Shimanek, "Chapter 7 — Occupational Health and Safety Aspects of Oil and Gas Extraction," *Environmental and Health Issues in Unconventional Oil and Gas Development*, edited by Debra Kaden, Tracie Rose, (Elsevier Inc. 2016), pp. 93-105, DOI: 10.1016/B978-0-12-804111-6.00007-8

26) Hagström, Earl L., Christopher Lyles, Mala Pattanayek, Bridgette DeShields and Mark P. Berkman, "Produced Water: Emerging Challenges, Risks, and Opportunities." *Environmental Claims Journal* 28 (2), 2016, pp. 122–39, DOI: 10.1080/10406026.2016.1176471; Shakhawat Chowdhury, Tahir Husain, Brian Veitch, Neil Bose, and Rehan Sadiq, "Human Health Risk Assessment of Naturally Occurring Radioactive Materials in Produced Water-A Case Study," *Human and Ecological Risk Assessment: An International Journal* 10, no. 6. December 1, 2004, pp. 1155–1171

27) "Fact Sheet, Produced Water: Oil and Gas Terminology Glossary," Water Environment Federation, 2018. <https://www.wef.org/globalassets/assets-wef/direct-download-library/public/03---resources/wsec-2017-fs-013-iwwc-og-glossary---final---5.21.18.pdf>

28) Hagström, Earl L., Christopher Lyles, Mala Pattanayek, Bridgette DeShields and Mark P. Berkman, "Produced Water: Emerging Challenges, Risks, and Opportunities," *Environmental Claims Journal* 28 (2), 2016, pp. 122–39, DOI: 10.1080/10406026.2016.1176471

According to a petroleum engineer who worked on Hadramawt's oil fields, a discussion with the management of an oil company in Yemen regarding the possibility of refining produced water for reuse did not go far. The top manager's response, the engineer said, was that if anyone gets sick or a "cow dies", blame will fall on the treated water and the company will be liable.⁽²⁹⁾ With no oversight mechanisms in place from the host country, oil companies have a record of lowering their compliance with international environmental standards.⁽³⁰⁾ A professor in the Department of Agriculture at the University of Sana'a, Dr. Mohammed Al-Hebshi, revealed that in the 1990s, when oil production was beginning to pick up, he took part in a study to assess the possibility of reusing treated produced water to irrigate animal feed crops but, according to Al-Hebshi, the idea was quickly dismissed by the Ministry of Oil and Minerals.⁽³¹⁾ Dr. Rashid Baraba, who served as oil minister from 2001 to 2006, said the technology to treat and reuse produced water was limited or non-existent in the 1990s, which made this idea infeasible in the context of Yemen.⁽³²⁾ Baraba, who has a PhD in geology, remains active in the oil sector as a consultant to public and private oil exploration companies.

The percentage of produced water naturally present in oil reservoirs varies widely and could range from 0-99 percent of the total liquids produced in oil extraction.⁽³³⁾ As the oil field matures, the ratio of produced water increases. Block 14 (Masila) was one of the first producing blocks in Yemen; its production started in 1993 and peaked in 2003 at 225,000 bpd.⁽³⁴⁾ In 1994, produced water in block 14 was 75 percent.⁽³⁵⁾ As it matured, produced water reached 95-99 percent; Canadian Nexen, the successor company to Canadian Occidental Petroleum Ltd., reported in 2008 that it was processing 2 million barrels of produced water a day in block 14.⁽³⁶⁾

A second petroleum engineer who worked in Hadramawt's oil fields jokingly said, "we have the capacity in Yemen to process millions of barrels a day, the

29) Sana'a Center interview with a petroleum engineer (#1) who has worked in Masila, August 13, 2020.

30) Chris Albin-Lackey, "Without Rules: A Failed Approach to Corporate Accountability," Human Rights Watch, 2013, https://www.hrw.org/sites/default/files/related_material/business.pdf

31) Sana'a Center interview with Dr. Mohammed Al-Hebshi, professor in the Faculty of Agriculture, Sana'a University, August 4, 2020.

32) Sana'a Center interview with Dr. Rasheed Baraba, former minister of oil and minerals, August 15, 2020.

33) Jerry Neff, Kenneth Lee and Elisabeth M. DeBlois, "Produced Water: Overview of Composition, Fates, and Effects," *Produced Water*, (New York: Springer New York, 2011), pp. 3-54, DOI: 10.1007/978-1-4614-0046-2_1

34) "Nexen Provides Update on Operations in Yemen," Nexen Inc., November 22, 2011, <https://www.globenewswire.com/news-release/2011/11/23/1362488/0/en/Nexen-Provides-Update-on-Operations-in-Yemen.html>

35) "Water Disposal in Masila-Hadramawt," The Welfare Social Society of Hadramawt and Canada's International Development Research Center, 2000, <http://hdl.handle.net/10625/32780>

36) "Nexen under pressure as Yemeni licence expires," September 25, 2011, <https://www.oilandgasmiddleeast.com/article-9476-nexen-under-pressure-as-yemeni-licence-expires>

problem is that it's water."⁽³⁷⁾ Asked whether it is financially viable to continue producing from such wells, another petroleum engineer who also worked in Hadramawt responded: "It isn't. Most companies would stop production when the water cut⁽³⁸⁾ reaches this level, but this is a state-run company⁽³⁹⁾ and they have other considerations,"⁽⁴⁰⁾ referring to the vested interests of subsidiaries, including security, transport and waste management companies that control the oil sector in Yemen and that prioritize continuing business operations over the sound management of natural resources.

Worldwide, produced water remains the largest volume waste stream in oil and gas production.⁽⁴¹⁾ Spillage of produced water poses a serious risk to the soil and may infiltrate groundwater, be it surface or deep ground water.⁽⁴²⁾ Without proper regulations and oversight in place, large volumes of produced water could pose a serious threat to water resources and the viability of the soil for agriculture. High salinity in produced water could contaminate shallow groundwater that Bedouins in the area rely on for their water supply and grazing. According to an EIA report done in Hadramawt in 2002, disposal methods for produced water are resulting in the dumping of "thousands of tonnes" of salt every year on the plateau, which is the watershed that feeds main tributary valleys in Wadi Hadramawt, damaging an already stressed vegetation and ecosystem.⁽⁴³⁾ A consultant who carried out several EIAs in Yemen said that he came across "a couple of solidified trees covered in salt" during his field visits.⁽⁴⁴⁾ A similar account was conveyed by a local from Wadi Ben Ali, who said vegetation is covered in a white sleet of what seems to be salt, causing trees to solidify and die.⁽⁴⁵⁾

37) Sana'a Center interview with a petroleum engineer (#2) who works on Masila, August 11, 2020.

38) "Oilfield Glossary: water cut," Schlumberger, last updated 2020, https://www.glossary.oilfield.slb.com/en/Terms/w/water_cut.aspx

39) This refers to PetroMasila, a state-run company founded in December 2011 under Cabinet Resolution 244 for the year 2011 to operate Block 14 after the PSA with Canadian Nexen ended. Its mandate has since expanded to cover key producing blocks in Hadramawt, 10, 14, 51 and 53 as well as Ash-Shihr Terminal, the main terminal for crude oil export in Yemen. See PetroMasila, <https://petromasila.com/about-us/>

40) Sana'a Center interview with a petroleum engineer (#3) who works on Masila, August 11, 2020.

41) Hagström, Earl L., Christopher Lyles, Mala Pattanayek, Bridgette DeShields and Mark P. Berkman, "Produced Water: Emerging Challenges, Risks, and Opportunities," *Environmental Claims Journal* 28 (2), 2016, pp. 122–39, DOI: 10.1080/10406026.2016.1176471.

42) John Pichtel, "Oil and Gas Production Wastewater: Soil Contamination and Pollution Prevention," Applied and environmental soil science, December 1, 2016, pp. 1–24; Tarek A. Ganat, Meftah Hrairi and Mysara Mohyaldinn, "Experimental Study to Evaluate the Environmental Impacts of Disposed Produced Water on the Surrounding Ecosystems," *International Journal of Environmental Science and Technology* (Tehran) 17, 2019, no. 3: 1439–1454.

43) Unpublished 2002 EIA report commissioned by an oil company and obtained by the Sana'a Center, Hadramawt, October 9, 2020.

44) Sana'a Center interview with an environmental impact consultant who carried out EIAs in Yemen from 2002-2010, October 9, 2020.

45) Sana'a Center interview with a resident of Wadi Ben Ali, August 17, 2020.

Spills may occur in a number of ways, including:

- Dumping produced water in open-air holding ponds,⁽⁴⁶⁾ which are lined with plastic to prevent produced water from seeping into the soil. Produced water is either left to evaporate or is re-injected into the oil reservoir to maintain its pressure. If not managed carefully, holding ponds can overflow, their plastic linings may break, especially in the hot and dry conditions of the Hadramawt plateau, or their contents may be washed away by rain and floods.⁽⁴⁷⁾
- Contamination of groundwater could occur when in-well casings are substandard or don't undergo a regular check, risking seepage of crude oil together with production chemicals into other ground formations including main freshwater aquifers during the extraction and reinjection processes.
- Reinjecting produced water into ground formations that contain freshwater or that interact with freshwater aquifers through fractures or faults instead of injecting it into a confined formation or back into the oil reservoir.
- Deliberately dumping produced water directly on the soil.
- Spillage from broken pipelines either due to lack of maintenance or acts of sabotage.⁽⁴⁸⁾
- Failing to regularly check casings and failing to insert monitoring tools in wells to detect faults and corrosion.
- Failing to regularly monitor and test water and soil samples to detect and limit contamination.

Based on the data gathered, there are plausible concerns that all of the above may be taking place on Yemen's oilfields, many of which are in Bedouin areas on the Hadramawt plateau, sitting on flood paths with tributaries feeding into farming and grazing lands that are at risk of being contaminated by chemical waste and produced water.

46) See Hagström, Earl L., Christopher Lyles, Mala Pattanayek, Bridgette DeShields and Mark P. Berkman, "Produced Water: Emerging Challenges, Risks, and Opportunities," *Environmental Claims Journal* 28 (2), 2016, pp. 122–39, DOI: 10.1080/10406026.2016.1176471

47) Unpublished 2008 assessment report following the 2008 floods in Hadramawt, commissioned by the governor, June 2008, and obtained by the Sana'a Center on August 26, 2020.

48) Sabotage of oil pipelines was common in Yemen even prior to the war. See, Boucek Christopher, Middle East Program No. 102, Carnegie Endowment for International Peace, September 2009. https://carnegieendowment.org/files/yemen_downward_spiral.pdf

Open-air Holding Ponds

Canadian Occidental Petroleum Ltd.'s discovery of commercial quantities of crude oil in the Masila basin in Hadramawt in 1991 came shortly after the first discovery made by Hunt Oil Co. in the Alif field of the Marib-Al-Jawf/Shabwa basin.⁽⁴⁹⁾

According to two petroleum company employees, both Canadian Occidental and the Yemeni government were in a rush to begin production; there was little regard for waste management and, for many years, produced water along with mud and brine were dumped into open-air holding ponds.⁽⁵⁰⁾ A similar account was given by Al-Hebshi, of the University of Sana'a, who visited the site in the late 1990s along with other Yemeni scholars to assess the possibility of re-using this water.⁽⁵¹⁾ Information from an environmental report in 2005⁽⁵²⁾ and an interview with Baraba, the Minister of Oil and Minerals from 2001-2006,⁽⁵³⁾ indicates that disposing of produced water in open-air ponds may have stopped. However, a draft report prepared by The Studies and Economic Media Center, a Yemeni non-governmental organization, together with the Yemeni chapter of the international alliance Parliamentarians Against Corruption, was presented at a workshop in Hadramawt in 2014, titled, "A Study on Transparency in Extractive Industries in Yemen." The report, supported by photographs and data from field visits, concluded that dumping produced water in holding ponds remained a widely common practice.⁽⁵⁴⁾ A resident of the area⁽⁵⁵⁾ and a petroleum engineer in the field confirmed similar accounts. The petroleum engineer, who still works in the Masila fields, said that "these ponds are widely used, and sometimes the companies don't even bother installing the plastic lining. They just dump the water on the ground."⁽⁵⁶⁾ If true, this would be a serious breach of international industry standards. Another petroleum engineer working on the Masila fields

49) Stephen J. Mills, "Oil Discoveries in the Hadramaut: How CanadianOxy Scored In Yemen," *The Oil & Gas Journal*, 90, No. 10: 49–, March 9, 1992.

50) Sana'a Center interview with a petroleum engineer (#3) who works on Masila, August 11, 2020.

51) Sana'a Center interview with Dr. Mohammed Al-Hebshi, professor in the Faculty of Agriculture, Sana'a University, August 4, 2020.

52) Unpublished 2005 environmental field report commissioned by an oil company, obtained by the Sana'a Center, Hadramawt, October 9, 2020.

53) Sana'a Center interview with Dr. Rasheed Baraba, former minister of oil and minerals, August 15, 2020.

54) "Draft Study on Extractive Industries in Yemen," The Studies and Economic Media Center and Yemeni Parliamentarians Against Corruption, Hadramawt, October 26, 2014, https://agora-parl.org/sites/default/files/lsnt_lstkhryjy_fy_lymn.pdf

55) Sana'a Center interview with a resident of Wadi Ben Ali, August 17, 2020.

56) Sana'a Center interview with a petroleum engineer (#3) who works on Masila, August 11, 2020.

said produced water is reinjected after separation from oil in the CPF into the oil reservoir. He declined to say how much or if all produced water in his area was disposed of in this manner.⁽⁵⁷⁾

A Google Maps satellite image of Block 51 in Hadramawt shows numerous square-shaped pits filled with dark substances and connected with pipes. While the images do not allow for any determination of the contents or whether the pits were built according to industry standards, a petroleum engineer currently working in the United Arab Emirates confirmed that they appear to be holding ponds for produced water.⁽⁵⁸⁾ Another petroleum engineer in Masila said that they were holding water to be injected into the reservoir to maintain its pressure. When pressed on the source of this water, whether it was produced water and under what conditions it was held, he declined to answer.⁽⁵⁹⁾ Advanced satellite image analysis has been used in other countries to monitor oil production activities and determine whether similar ponds contain produced water or freshwater; this could be one way to determine the environmental impact activities in oil production in Yemen, particularly given the restrictions facing environment inspectors from accessing oilfields.

Figure 3:



Satellite image of apparent holding ponds, Block 51, Hadramawt.

Source: Google Maps, accessed August 25, 2020.

57) Sana'a Center interview with a petroleum engineer (#2) who works on Masila, November 26, 2020.

58) Sana'a Center interview with petroleum engineer (#4) who works in the United Arab Emirates, August 17, 2020.

59) Sana'a Center interview with a petroleum engineer (#2) who works on Masila, November 26, 2020.

Figure 4:***Zoom in on one holding pond, Block 51, Hadramawt***

Source: Google Maps, accessed August 25, 2020.

A resident of Wadi Ben Ali has been working with a group of university students and graduates to bring attention to the issue of pollution in the areas around the oil fields. “When it flooded in Hadramawt in 2008, a black oily substance reached residential areas and leached onto the rocks. The oil company paid residents to clean it up using domestic tools,” he said.⁽⁶⁰⁾

The Sana’a Center obtained a copy of a report commissioned by the governor of Hadramawt in June 2008 to assess damage following residents’ complaints that flood water containing oil residue had reached their villages along Wadi Ben Ali. Laboratory results of water and soil samples from a 20-kilometer stretch on

60) Sana’a Center interview with a resident of Wadi Ben Ali, August 17, 2020.

Wadi Ben Ali, tested by the University of Hadramawt for Science and Technology, revealed water samples that almost uniformly contained higher levels of mercury than Health Ministry regulations permit for drinking and irrigation, while all soil samples collected from the area contained oil residue.

The assessment found that holding ponds in Block 10 containing produced water and production chemicals were placed in the flood path on the mountain plateaus (the watershed of Wadi Hadramawt) and flowed down into the valley. According to the assessment report, there are 30 villages in the valley where onions, fruits, dates and beans are grown, and livestock grazing is widely practiced. The report states that some farmers opted not to plant their crops for the season, fearing contaminated produce. The assessment recommended that the oil company compensate local residents, though it is not clear if this happened. It also recommended the company not place holding ponds on flood paths,⁽⁶¹⁾ and that the area be included in the company's community projects and its residents be provided employment and training opportunities.⁽⁶²⁾

Local media has reported on residents finding heavy oil residue in water sources in Sah, Dhulai'a and Ghail Ben Yamin districts.⁽⁶³⁾ Interviews with key informants also revealed that problem areas are Dhulai'a (exploration block 49), Sah (with the main production blocks in Hadramawt, 10, 14 and 51) and Ghail ben Yamin (overlaps with production block 14 and also exploration blocks 68, 43 and 83). According to the director general of the National Center of Public Health Laboratories in Hadramawt and head of the Hadramawt Cancer Foundation, Dr. Walid Al-Bataty, Dhulai'a has witnessed a noticeable increase over the past 20 years in cancers and kidney and liver diseases.⁽⁶⁴⁾ Residents have also reported coming across oil residue while digging shallow wells or when it floods, livestock perishing unexpectedly, and people experiencing "strange" illnesses. According to Ba Surrah, who has been receiving residents' complaints on this matter since entering parliament in 1997, health complaints also have included reports of birth deformities.⁽⁶⁵⁾ However, the lack of comprehensive reports on these

61) Locals are familiar with the paths through which rain and floods flow, and the report suggested oil companies make use of this local knowledge when planning where to collect waste related to oil production.

62) Unpublished 2008 assessment report following the 2008 floods in Hadramawt, commissioned by the governor, June 2008, and obtained by the Sana'a Center on August 26, 2020.

63) "Hadramawt, Residents of Sah Fear Oil Pollution [AR]" Al-Arabi, March 7, 2018, <https://www.al-arabi.com/s/21111>; "Hadramawt: Risking Groundwater While Leukaemia Threatens the Residents of the Plateau [AR]," TV Aden, January 7, 2020, <https://www.youtube.com/watch?v=C8zmL1F05x0>

64) Sana'a Center interview with Dr. Walid Al-Bataty, director general of the National Center of Public Health Laboratories in Hadramawt and head of the Hadramawt Cancer Foundation, August 13, 2020.

65) Sana'a Center interview with Muhsen Ba Surrah, member of parliament 1997-present, August 19, 2020.

incidents leaves much room for speculation on causes of, or responsibility for, such incidents. Ba Surrah said that he, along with other MPs from Hadramawt, raised the issue in parliament, but little was done. According to Ba Surrah, “oil companies only respond to the president and prime minister’s offices, they don’t respond to the local authority.”⁽⁶⁶⁾

Injecting Produced Water into the Ground

Al-Hebshi carried out a study as the head of an association called The Welfare Social Society of Hadramawt together with Canada’s International Development Research Center in 2000. The report discusses extensively the issue of groundwater contamination that may result from improper disposal of produced water.⁽⁶⁷⁾ It refers to another study commissioned by Canadian Occidental Petroleum Ltd., which suggested that injecting produced water into a ground formation called Harshiyat sandstones – below the large Mukalla freshwater aquifer and above the oil reservoir – could be a viable option for disposal.⁽⁶⁸⁾ Baraba said he became aware of oil companies injecting produced water into Harshiyat sandstones when he took office at the Ministry of Oil and Minerals in 2001. He said he “stopped it immediately” and approved the purchase of equipment that would allow for the separation of oil from water at the well and a compressor so produced water could be reinjected into the oil reservoir in the Qishn formation.⁽⁶⁹⁾

Figure 5 below shows the stratigraphic section of the Masila basin. The oil reservoir is in the Qishn formation. The Harshiyat sandstone formation is separated by limestone from the Mukalla sandstones, site of a high-quality water aquifer.

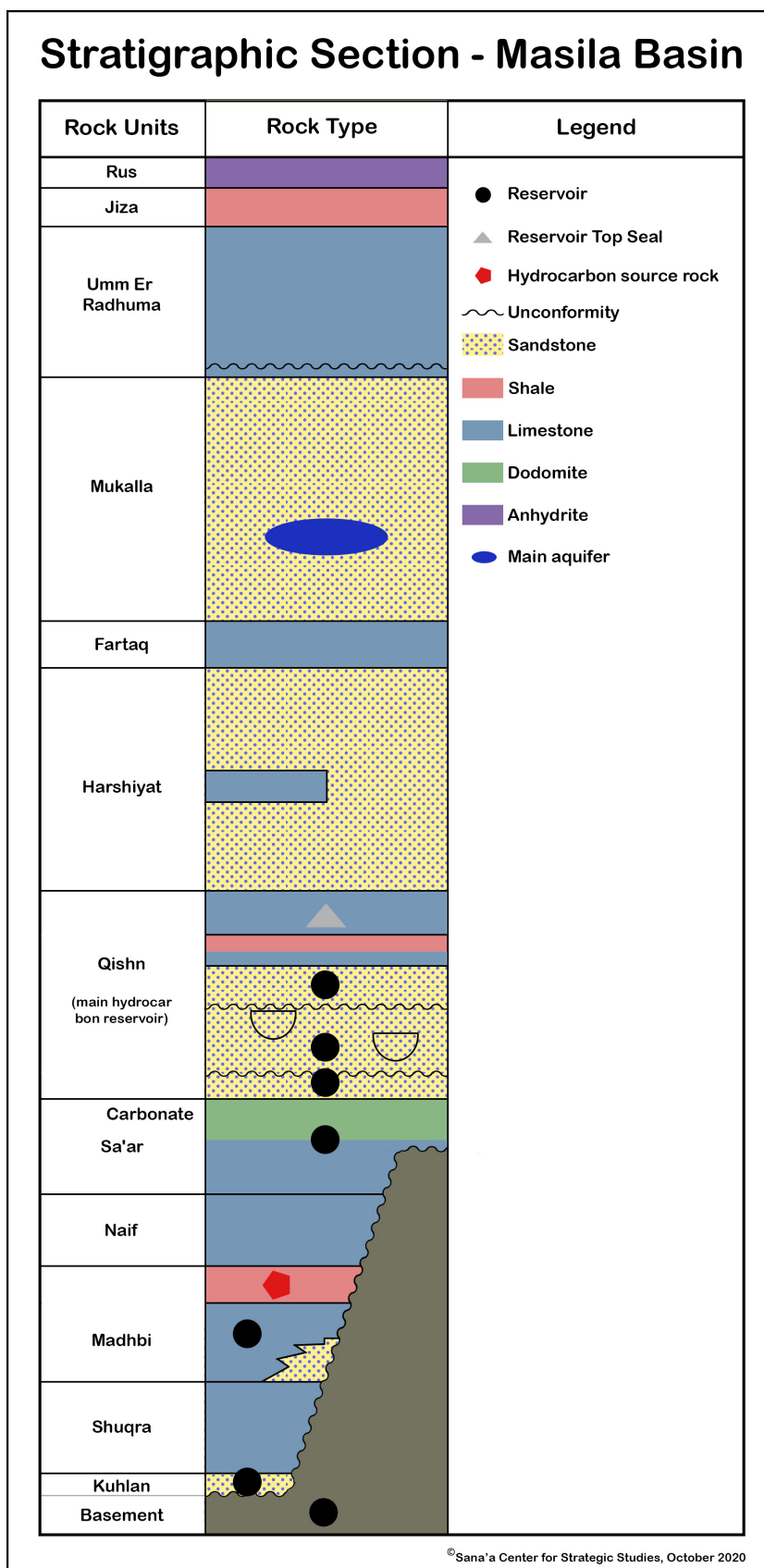
66) Ibid.

67) See also, Mohammed A. Al-Hebshi, “Disposal of Water Accompanying Oil production and Underground water Pollution in Hadramawt”, (n.d.) https://www.academia.edu/15534779/Disposal_of_Water_Accompanying_Oil_production_in_Hadramawt?source=swp_share

68) In 1996, an assessment of groundwater in Mukalla aquifer was carried out by Komex, commissioned by Canadian Oxy, Canadian Occidental Petroleum, the Canadian International Development Agency and the Government of Yemen. See a summary of the assessment project, Paul E. Hardisty, John Watson, and Stephen D. Ross, “A Geomatics Platform for Groundwater Resources Assessment and Management in the Hadramout-Masila Region of Yemen,” IAHS no. 235, April 1996, pp. 527-533,

69) Sana’a Center interview with Dr. Rasheed Baraba, former minister of oil and minerals, August 15, 2020.

Figure 5:



Source: Hakimi, Mohammed Hail and Saddam A. Al-Sufi, 2018.⁽⁷⁰⁾

70) Mohammed Hail Hakimi and Saddam A. Al-Sufi, "Organic Geochemistry Investigations of Crude Oils from Bayoot Oilfield in the Masila Basin, East Yemen and Their Implication for Origin of Organic Matter

According to petroleum engineers, reinjecting produced water into an oil reservoir is an international industry standard. This helps maintain the pressure of the reservoir and slows down its depletion rate.⁽⁷¹⁾ According to one petroleum engineer, some companies operating in the concession blocks do reinject water into the oil formations to enhance production, but he wasn't certain if all of the companies have the powerful and costly compressors needed to do so.

Further, it is not clear that the companies that have the tools to reinject it are indeed doing so with all of the produced water or only enough to enhance production while the rest is disposed of through other previously discussed methods. It is also difficult to determine without a proper field inspection whether oil companies have stopped injecting into shallower formations as Baraba suggested.

Waste and Leftover Material from Exploration Activities

There are currently 14 exploration concession blocks in Hadramawt, and 26 in the country overall.⁽⁷²⁾ According to Sami al-Jawhi, an environmental engineer who attempted to take samples from exploration areas and test them in the university laboratory in Hadramawt with two other colleagues, there is a serious concern about companies leaving behind industrial waste material — metals, empty barrels, and even sacks of chemicals used in drilling and well stimulation.⁽⁷³⁾ A similar account was given by Sameeha Mohammed, a physics graduate student of Taiz University and a Mukalla resident. She said that for her master's thesis she gathered samples from exploration areas and sent them to the laboratory of the National Atomic Energy Commission in Sana'a in 2013, but the lab never returned the results.⁽⁷⁴⁾ After trying and failing many times to get a response from the laboratory, she abandoned the research she had started and switched

and Source-Related Type," *Egyptian Journal of Petroleum* 27, no. 1. March 2018. pp. 37–54. The stratigraphic section *modified from* Beydoun, Z.R., International Union of Geological Sciences, International Commission on Stratigraphy and Yemen Ministry of Oil and Minerals. *International Lexicon of Stratigraphy: Republic of Yemen*, (IUGS and Ministry of Oil and Mineral Resources, Republic of Yemen, 1998).

71) Sana'a Center interviews with petroleum engineers (#1), August 13, 2020; (#2), August 11, 2020; (#3), August 11, 2020; and (#4), August 17, 2020; *See also*, "Oilfield Glossary: depletion", Schulmberger, last updated 2020, <https://www.glossary.oilfield.slb.com/en/Terms/d/depletion.aspx>

72) "Concession Map Overview," Petroleum Exploration and Production Authority, The Republic of Yemen, last updated, 2012. <http://www.pepa.com.ye/Concession/concession.htm>

73) Sana'a Center interview with Sami Al-Jawhi, environmental engineer, August, 18, 2020.

74) Sana'a Center interview with Sameeha Mohammed, head of the Public Administration for Management Development Research, Mukalla, August 20, 2020.

to another major. However, she said she had visited the exploration sites, with the help of a deputy governor who was from that area,⁽⁷⁵⁾ and saw wells sloppily covered with heaps of sand and abandoned industrial equipment.⁽⁷⁶⁾

The 2014 draft report by the Studies and Economic Media Center and the Yemeni Parliamentarians Against Corruption described numerous incidents documented by committees that were sent to the field for inspections after residents' complaints reached the prime minister's office. The report suggests that locals took waste materials left by oil companies in exploration blocks and repurposed them for domestic use.⁽⁷⁷⁾ Al-Bataty confirmed this and said that this had led to several people getting sick. According to Al-Bataty, it is not known if the materials contained chemical toxins or NORM, but in one instance several members of the same family got sick within a span of a couple of months after using empty barrels left behind by an oil company.⁽⁷⁸⁾ Baraba, the former minister, recalled a similar incident, saying it had happened during his time in office and that he directed the affected families be sent abroad for treatment.⁽⁷⁹⁾

According to Al-Bataty, companies doing exploration activities have left behind industrial waste that continues to have impacts years later. A 2005 unpublished field report inspecting the use of oil drums among Bedouins reveals widespread use of materials disposed of by oil companies, including more than a half-dozen drums found among Bedouins around Masila.⁽⁸⁰⁾ The report warns that BTEX chemicals used in oil production and other toxins leach into the plastic, making it impossible to clean these drums to a level rendering them safe for domestic use.⁽⁸¹⁾ While the report suggests some measures were taken to ensure these drums would not be used by the Bedouins, such as paying a local military commander a large sum to oversee their proper disposal, a local resident said they are still seen in the area although people have become more wary of them.⁽⁸²⁾

75) Concession areas are highly securitized and it is not easy to access them and collect samples without a permit.

76) Sana'a Center interview with Sameeha Mohammed, head of the Public Administration for Management Development Research, Mukalla, August 20, 2020.

77) "Draft Study on Extractive Industries in Yemen," The Studies and Economic Media Center and Yemeni Parliamentarians Against Corruption, Hadramawt, October 26, 2014, https://agora-parl.org/sites/default/files/lsnt_lstkhryjy_fy_lymn.pdf

78) Sana'a Center interview with Dr. Walid Al-Bataty, director general of the National Center of Public Health Laboratories in Hadramawt and head of the Hadramawt Cancer Foundation, August 13, 2020.

79) Sana'a Center interview with Dr. Rasheed Baraba, former minister of oil and minerals, August 15, 2020.

80) Unpublished 2005 environmental field report commissioned by an oil company, obtained by Sana'a Center, Hadramawt, October 9, 2020.

81) Ibid.

82) Sana'a Center interviews with a petroleum engineer (#3) who works on Masila, August 11, 2020, and with a resident of Wadi Ben Ali, August 17, 2020.

Unmaintained Wells

Another pollution risk suggested by available data relates to the disruption of crude oil production in Yemen. Large scale oil production in Yemen began in 1988 with 170,000 bdp, peaking in 2002 at 457,000 bdp,⁽⁸³⁾ before declining on average by 6.5 percent annually between 2001-2014.⁽⁸⁴⁾ It spiralled further downward after the onset of the ongoing conflict and hit a record low in 2016, averaging only 24,000 bpd. In 2015, foreign oil companies halted their operations in Yemen except for some limited production in blocks operated by state-run companies, Safer and PetroMasila.⁽⁸⁵⁾ Crude oil production in Hadramawt in 2019 reached an average of 33,000 bdp.⁽⁸⁶⁾ This is only 7.2 percent of peak production.

The lengthy disruption due to the conflict and withdrawal of foreign oil companies may result in oil wells being no longer viable. To restore them they must undergo a process called 'well workover' – often involving replacing tubing and injecting acids and additives to stimulate production⁽⁸⁷⁾ – or the wells are considered dead and should be sealed and abandoned. Properly abandoning wells – which involves sealing them to prevent leakages and dismantling and removing all equipment and materials from the site – is a highly technical and costly process.⁽⁸⁸⁾ Otherwise, 'orphaned' wells that are no longer in use pose a long-term pollution threat from leakages into the surrounding environment, such as if the inner metal casings corrode. This could also happen with wells that are still in use but are not undergoing due inspection and maintenance to ensure that there are no faults in the casing.

83) "Statistical Review of World Energy – all data, 1965-2019", BP: Statistical Review of World Energy, accessed December 3, 2020, <https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>

84) "Yemen Socio-Economic Update 2016," Ministry of Planning and International Cooperation, Government of Yemen, Issue (12), March 2016, https://reliefweb.int/sites/reliefweb.int/files/resources/yseu12_english_v4_final.pdf

85) "Yemen Economic Monitoring Brief," World Bank, 2019, <https://reliefweb.int/sites/reliefweb.int/files/resources/135266-YemEconDevBrief-Winter-2019-English-12-Mar-19.pdf>

86) "Yemen Economic Update," World Bank, December 2019, <http://pubdocs.worldbank.org/en/360391580209593452/Yemen-Update-Dec-2019.pdf>

87) "Oilfield Glossary: workover and intervention," Schlumberger, last updated 2020, <https://www.glossary.oilfield.slb.com/en/Disciplines/Well-Workover-and-Intervention.aspx>

88) Sana'a Center interview with a petroleum engineer (#1) who has worked in Masila, August 13, 2020; Sana'a Center interview with petroleum engineer (#4) who works in the United Arab Emirates, August 17, 2020.

Air Pollution

The operations of companies in Hadramawt's oil producing blocks focus on crude oil, while the accompanying natural gas is generally just flared off, releasing toxins, soot and particulate matter into the air.⁽⁸⁹⁾ There is no available information regarding how much gas is flared, but an oil company employee in the field said the practice is widespread and the amount of gas is significant. In 2016, the governorate commissioned PetroMasila to construct an electricity plant and operate it using gas from Block 10 instead of flaring it. Currently this plant supplies most of the electricity in Wadi Hadramawt.⁽⁹⁰⁾ However, other blocks continue to burn off gas with no regard to air pollution. A similar account was provided by Omar Shehab, the director general of the Hadramawt office of the EPA.⁽⁹¹⁾

89) Solomon Giwaa, Collins Nwaokochaa, Sidikat Kuyeab and Kayode Adamaa, "Gas flaring attendant impacts of criteria and particulate pollutants: A case of Niger Delta region of Nigeria," *Journal of King Saud University - Engineering Sciences* Volume 31, Issue 3, July 2019, pp. 209-217, <https://www.sciencedirect.com/science/article/pii/S1018363917300363>. See also Olusegun Fawoleac, X.-M.Caia, A.R.MacKenzie, "Gas flaring and resultant air pollution: A review focusing on black carbon", *Environmental Pollution* Volume 216, September 2016, pp. 182-197, <https://www.sciencedirect.com/science/article/abs/pii/S0269749116304638>

90) Sana'a Center interview with a petroleum engineer (#3) who works on Masila, August 11, 2020.

91) Sana'a Center interview with Omar Shehab, director general of the Hadramawt office of the EPA, August 15, 2020.

HEALTH CONCERNS

Anecdotes of health problems suffered by people in the concession areas were repeatedly mentioned by a number of informants as well as in the limited available literature. However, there are no proper and comprehensive studies that can establish the extent to which certain diseases are increasing and whether these are linked to pollution caused by oil production and exploration activities. The Hadramawt Cancer Foundation suspected an increase in cancer cases that may have been linked to oil production activities, and it established a Cancer Registry in 2006. Report findings suggest that incidents of reported cancers in females increased from 20 per 100,000 in 2001–2005 to 30 per 100,000 in 2006–2010, and reached 55.9 per 100,000 in 2011–2015. For males, it was 15.2, 24.6 and 46.8 per 100,000, for the same respective time periods.⁽⁹²⁾

According to the same report, the three most prevalent cancer types were breast cancer, lymphoma and leukemia. Children also were getting sick; 8.5 percent of the cases reported between January 2011 and December 2015 were in children, with the three most prevalent cancer types among children being leukemia, lymphoma and brain cancer.

A document obtained by the Sana'a Center from The National Oncology Center in Hadramawt shows an alarming increase in numbers of patients admitted between 2016 and 2018. In 2017, there was an increase in admittances of 18 percent from 2016, and 2018 witnessed a 34 percent increase compared to 2017. According to admittances recorded on this document, the number of female cancer patients was 44 percent higher than male patients for the 2016-2018 period.⁽⁹³⁾

According to Al-Bataty, the director general of the National Center of Public Health Laboratories in Hadramawt who also heads the Hadramawt Cancer Foundation, “the results of the report show an obvious increase, but no one is trying to establish whether this is happening because of the oil operations, and so the residents do not get any compensation or medical support. What is worse is that because these are categorized as chronic diseases, they don’t qualify for medical humanitarian aid [during the war years].”⁽⁹⁴⁾ Al-Bataty added that the association he leads provides diagnosis, chemotherapy and medication to the patients using donations from philanthropists and through organizing fundraising events during Ramadan.

92) Abobaker Ahmed ba’amer, Zaki Faraq Sanoon, Ahmed Mohammed Badheeb and Alaa Awadh Miftaah, “Cancer Incidence Report 2011-2015,” Hadramawt Cancer Registry, Hadramawt Cancer Foundation and Al-Awn Foundation for Development, obtained August 23, 2020; The report covered Hadramawt, Shabwah, Al-Mahrah and Socotra, 80 percent of the cases in the Cancer Registry were from Hadramawt.

93) “Statistics of Patients in the National Oncology Center in Hadramawt Alwadi and Alsahra for the years 2016-2018,” National Oncology Center, Hadramawt Alwadi, The Ministry of Health Population, unpublished document obtained by Sana’a Center August 23, 2020. The document is not dated, but it is signed and stamped by Dr. Hisham Sumayt, director of the National Oncology Center in Hadramawt and bears the center’s logo.

94) Sana’a Center interview with Dr. Walid Al-Bataty, director general of the National Center of Public Health Laboratories in Hadramawt and head of the Hadramawt Cancer Foundation, August 13, 2020.

POLITICAL AND SOCIAL CONTEXTS

The problem at hand is undoubtedly complex. The oil and gas industry was the largest source of public revenue in Yemen until production fell 77 percent in 2015.⁽⁹⁵⁾ The decline in oil output since its early 2000s peak has intensified competition among Yemeni elites to secure their share of a shrinking resource.⁽⁹⁶⁾

The entanglement of the oil sector in state corruption and patronage networks has been well-documented⁽⁹⁷⁾ and has involved local subcontractors who provide security, transport and other energy sector services along with energy and oil shell companies registered in tax havens such as the Cayman Islands and Panama.⁽⁹⁸⁾ Although Yemen joined the Extractive Industry Transparency Initiative in 2007, its membership has been riddled with problems. Yemen was suspended for noncompliance three times; in 2015, it was suspended indefinitely.⁽⁹⁹⁾

Thus, it is not possible to properly assess the environmental impact of Yemen's oil industry without understanding the political, economic and security backdrop in which it operates. The opaqueness of dealings connected to the oil sector becomes obvious to anyone who attempts to research the topic. People are afraid to speak and it is challenging to find consistent records or follow the trails of all the companies and contractors involved. Attempts to speak with current Ministry of Oil and Minerals officials in Hadramawt were unsuccessful. One deputy responded: "We have attempted many times to obtain information from the oil companies but to no avail. I don't have any information in this regard that will

95) "Yemen Socio-Economic Update 2016," Ministry of Planning and International Cooperation, Government of Yemen, Issue (12), March 2016, https://reliefweb.int/sites/reliefweb.int/files/resources/yseu12_english_v4_final.pdf

96) Peter Salisbury, "Yemen's Economy: Oil, Imports and Elites," Chatham House, Middle East and North Africa Programme Paper, MENA PP 2011/2012, October 2011, https://www.chathamhouse.org/sites/default/files/1011pp_yemeneconomy.pdf; "Yemen Corruption Assessment," USAID, September 25, 2006, <https://photos.state.gov/libraries/yemen/231771/PDFs/yemen-corruption-assessment.pdf>

97) "White Paper: Combating Corruption in Yemen," Sana'a Center for Strategic Studies, November, 2018. http://sanaacenter.org/files/Rethinking_Yemens_Economy_No4_En.pdf; Peter Salisbury, "Yemen's Economy: Oil, Imports and Elites," Chatham House, Middle East and North Africa Programme Paper, MENA PP 2011/2012, October 2011, https://www.chathamhouse.org/sites/default/files/1011pp_yemeneconomy.pdf; Sarah Phillips, "Al-Qaeda and the Struggle for Yemen," *Survival* 53, no. 1, February 1, 2011, pp. 95–120, DOI: 10.1080/00396338.2011.555605; "Yemen Corruption Assessment," USAID, September 25, 2006, <https://photos.state.gov/libraries/yemen/231771/PDFs/yemen-corruption-assessment.pdf>

98) Dato Capital: Search International Private Companies and Directors, accessed August 27, 2020, https://en.datocapital.com/_search?q=yemen&dirf=0&country=PA&list=1

99) "Status of Yemen," Extractive Industries Transparency Initiative (EITI), last updated December 20, 2018, <https://eiti.org/yemen>

help your research.”⁽¹⁰⁰⁾ Another contact attempt with another deputy from the same ministry went unanswered.

The issues key informants brought up seemed to be well known among community members but officially unacknowledged. Two of the researchers who had to abandon their research after having collected samples said they believed their work was intentionally impeded because of the political sensitivity of the issue. Al-Jawhi said that the dean of the Faculty of Environment in Hadramawt University told him and his two colleagues that the work they were doing was too sensitive and would bring trouble. They had to switch to another field site altogether.⁽¹⁰¹⁾ Sameeha Mohammed said she felt extremely frustrated because she saw industrial waste when she collected her research samples. While she has abandoned her physics master’s program for the moment and earned a master’s in management instead, she said she still would like the lab results for her tests.⁽¹⁰²⁾

100) Sana’a Center communication with an official from the office of the Ministry of Oil and Minerals in Hadramawt, August 19, 2020.

101) Sana’a Center interview with Sami Al-Jawhi, environmental engineer, August, 18, 2020.

102) Sana’a Center interview with Sameeha Mohammed, head of the Public Administration for Management Development Research, Mukalla, August 20, 2020.

LEGAL CONTEXT AND THE AUTHORITIES RESPONSIBLE FOR SAFEGUARDING THE ENVIRONMENT

Legally, the Ministry of Oil and Minerals is responsible for developing the regulatory framework for sound extractive industry operations and for coordinating with relevant parties to take the necessary precautionary measures that safeguard against spills of harmful chemicals.⁽¹⁰³⁾ While the Ministry of Water and Environment has a more expansive portfolio with regard to environmental protection, it is not mandated to oversee extractive industries. There is an environmental protection law (26) that stipulates the role of environmental inspectors to check and report violations, however it does not mandate a particular authority with this role and with enforcing regulations.⁽¹⁰⁴⁾

There is an environment department in the Ministry of Oil and Minerals under the Occupational Safety Authority. From the interviews and some reports, inspectors from this department visited the oil field sites occasionally and gathered reports, however, it is not clear if this practice continued, and it is unclear whether these inspections resulted in any meaningful response. The message from one of the deputies in the Hadramawt office of the Ministry of Oil and Minerals indicates the ministry cannot get access to the oil company reports.⁽¹⁰⁵⁾ The Ministry of Water and Environment seems to have been sidelined from anything relating to the extractive industries based on interviews with Lutf Al-Eryani, a former minister of water and environment⁽¹⁰⁶⁾ as well as Ammar Al-Awlaqi, the deputy minister of water and environment and acting chairman of the EPA,⁽¹⁰⁷⁾ and Shehab, the director general of the EPA in Hadramawt.⁽¹⁰⁸⁾

103) “Presidential Decree (40) for the year 2000 regulating the Ministry of Oil and Minerals [AR],” The National Center for Information, the Republic of Yemen, February 16, 2000, <https://yemen-nic.info/ministations/detail.php?ID=10203>

104) “Law No. 26 for the Year 1995 on the Protection of the Environment,” The National Center for Information, The Republic of Yemen, October 29, 1995, https://yemen-nic.info/db/laws_ye/detail.php?ID=11458

105) Sana’a Center personal communication with an official from the office of the Ministry of Oil and Minerals in Hadramawt, August 19, 2020.

106) Sana’a Center interview with Dr. Lutf Al-Eryani, former minister of water and environment, August 18, 2020.

107) Sana’a Center interview with Ammar Al-Awlaqi, the deputy minister of water and environment and acting EPA chairman), August 20, 2020.

108) Sana’a Center interview with Omar Shehab, director general of the Hadramawt office of the EPA,

According to Al-Awlaqi, the EPA received several complaints from residents and, in Shabwa governorate, found that, indeed, a pipe was leaking and spilling oil. He said that generally there is a lot of resistance to allowing inspectors from the EPA to visit the sites. EPA inspectors recently sent letters to oil companies to organize field visits and, even though these visits were to be coordinated with the Ministry of Oil and Minerals and PEPA, Al-Awlaqi said the companies in Hadramawt refused to grant access.

“What we want to do is visit the sites and make sure that the companies are following their industry standards. We don’t have any intention to hinder their work,”⁽¹⁰⁹⁾ Al-Awlaqi said. He said when he discussed the matter with the prime minister, Ma’een Abdulmalek, the response was, “we have no red lines, we support whatever is beneficial for the environment so long as it doesn’t obstruct operations in the oil sector.”⁽¹¹⁰⁾ Al-Awlaqi added that without a pro-environment delegation within the government, oil company operations would continue to go unchecked.⁽¹¹¹⁾

The National Dialogue Conference of 2013–2014 that sought to shape recommendations on a wide variety of state-building issues stated the need for “a general oil law.” Such a law could be designed to ensure the transparency of contracting agreements in the sector, including those offered to oil companies and energy service subcontractors, and as envisioned it would establish a mechanism for a more equitable distribution of oil wealth. Several recommendations pertained to the environment and public health, but no link was made between them and extractive industries.⁽¹¹²⁾

August 15, 2020.

109) Sana’a Center interview with Ammar Al-Awlaqi, the deputy minister of water and environment and acting EPA chairman, August 20, 2020

110) Ibid.

111) Ibid.

112) “National Dialogue Conference Document 2014-2013,” The National Conference for an Inclusive National Dialogue, The Republic of Yemen, 2014, <https://www.peaceagreements.org/viewmasterdocument/1400>



THE ROLE OF THE LOCAL AUTHORITY

Hadramawt has been moving toward greater autonomy with the launch of the Hadramawt Inclusive Conference in 2017⁽¹¹³⁾ and in securing from the central government a commitment to keep 20 percent of revenues from crude oil produced in and exported from the governorate. Previously, Hadramawt retained none of the profits. However, when it comes to regulating the operations of oil companies, the local authority seems to be sidelined.

According to an official in the governor's office who spoke on condition of anonymity, the office has been getting many complaints from residents in exploration concession blocks of people falling ill and of finding oil residue when digging shallow wells. However, this official said the matter is sensitive and no one wants or dares to open that file. PetroMasila, a state-run oil company, is completely unresponsive to the local authority's requests for information and reports, he said, adding that "even inspectors from the office of the Ministry of Oil and Minerals are not given access anymore."⁽¹¹⁴⁾

113) Adel Al-Ahmadi, "Inclusive Hadramawt Conference Launches Today: Protecting the Governorate First, Adel Al-Ahmadi [AR]," *The New Arab*, April 22, 2017, <https://www.alaraby.co.uk/>

114) Sana'a Center interview with Hisham Al-Saidi, deputy governor, Hadramawt, August 18, 2020.

THE COMMUNITY'S LIMITED ROLE

Some associations and civil society activists have been working to raise awareness of the damage to the environment, livelihoods and health thought to be linked to oil company operations in Hadramawt, such as through organizing lectures to discuss such matters. According to Al-Hebshi, the professor of agriculture in the University of Sana'a, there were some small-scale protests.⁽¹¹⁵⁾ But others say that locals cannot even approach the high-security areas to protest let alone to submit demands to the oil companies.⁽¹¹⁶⁾

According to Haitham al-Jaberi, a petroleum engineering graduate and the head of the Sons of Al-Jaberi Charity and Cultural Association, community-level influence in these issues is limited because most residents are poor and uneducated farmers or herders, who have hardly a clinic or a school in their areas. When they see material left by oil companies, they take it and turn it into useful implements, such as pots or barrels to store water and feed their cattle.⁽¹¹⁷⁾ When asked if there are any community projects by the companies, Al-Bataty said small projects exist, which he dismissed as spending more on public relations and marketing than on the projects themselves.⁽¹¹⁸⁾ Looking at the current community projects of the two operating companies in Hadramawt, PetroMasila and Calvalley Petroleum (Cyprus) Ltd., PetroMasila runs an internship program for students in Hadramawt's higher education institutions,⁽¹¹⁹⁾ while Calvalley lists a few small-scale projects with budgets under \$100,000.⁽¹²⁰⁾

115) Sana'a Center interview with Dr. Mohammed Al-Hebshi, professor in the Faculty of Agriculture, Sana'a University, August 4, 2020.

116) Sana'a Center interview with Haitham Al-Jaberi, Sons of Al-Jaberi Charity and Cultural Association, August 17, 2020.

117) Ibid.

118) Sana'a Center interview with Dr. Walid Al-Bataty, director general of the National Center of Public Health Laboratories in Hadramawt and head of the Hadramawt Cancer Foundation, August 13, 2020.

119) Internship programs run 14 days or less, a resident of Wadi ben Ali told the Sana'a Center in an interview, August 17, 2020; "Community Social Responsibility," PetroMasila, last updated 2020, <https://petromasila.com/csr/>

120) "Sustainability," Calvalley Petroleum (Cyprus) Ltd., accessed August 27, 2020, <https://www.calvalleypetroleum.com/sustainability-the-environment-2/>

INTERNATIONAL ARBITRATION BY THE GOVERNMENT OF YEMEN

The Government of Yemen has taken several oil companies to international arbitration, usually over contractual issues. The Yemeni side was represented multiple times by a team from UK-based law firm, Clyde & Co. In July 2019, the Yemeni government was issued an award of close to US\$30 million plus 60 percent of legal and procedural costs in a case it brought against a number of oil companies that operated Block 53, namely, the UK's Dove Energy and Petrolin, a subsidiary of Norway's DNO, and MoE Oil & Gas Yemen, which is registered in the Cayman Islands.⁽¹²¹⁾

Another case is still in court in Paris against Nexen, the details of which have not been publicized. However, according to Baraba and a petroleum engineer who worked on Hadramawt's oil fields, the case against Nexen is related to environmental issues.⁽¹²²⁾ Neither the government nor Yemeni media announce such international arbitration cases and settlement conditions to the public. If the Government of Yemen has received settlement awards, it is not clear where that money has gone. There is no indication it has been used to compensate local residents for damaged crops or water wells.

121) Cosmo Sanderson, "Yemen Wins Damages Over Abandoned Oil Block," *Global Arbitration Review*, July 31, 2019, <https://globalarbitrationreview.com/article/1195832/yemen-wins-damages-over-abandoned-oil-block>

122) Sana'a Center interviews with Dr. Rasheed Baraba, former minister of oil and minerals, August 15, 2020, and with petroleum engineer (#3) who works on Masila, August 11, 2020.



LOOKING AHEAD

The environmental and social impact of oil operations and exploration in concession areas in Hadramawt and elsewhere in Yemen is entangled with Yemen's main ailments: corruption, questionable dealings of a few powerful elite, Yemen's squandered wealth and natural resources, economic collapse and the securitization and militarization of much of the country. It is impossible to approach this issue without stumbling upon all these larger problems. However, considering the indications of immediate health concerns and the potential damage to Yemen's soil and groundwater, this is also a pressing issue that can be mitigated through some immediate and mid-term policy actions.

RECOMMENDATIONS

Studies and Knowledge Production:

- Fill the alarming knowledge gaps by initiating comprehensive studies of the environmental, health and social impact of the oil industry's activities up until now in all areas surrounding concession blocks.
- Hadramawt's move toward greater autonomy provides a good opening to engage the local authority to take a proactive approach to the matter, collect field visit reports and residents' complaints in one common register in the governorate.
- The local authority in coordination with the Ministry of Water and Environment should engage the local ministry and EPA offices to conduct inspections and field visits and gather soil and water samples periodically to be able to compare over time changes in quality and composition.
- The EPA should pass on some of its acquired know-how to strengthen the capacity of its local office.
- Provide the National Center of Public Health Laboratories in Hadramawt with the know-how and equipment to gather and analyze soil and water samples and compare the results over time.
- Deploy GIS technology as a tool for environmental monitoring of leaks and the use of open-air ponds.

Legal:

- The government of Yemen should review its PSA granting regulations and, prior to signing one with any oil company, demand comprehensive environmental impact assessments, a comprehensive waste management plan, and a plan to ensure that reservoirs are appropriately managed so as to avoid their premature depletion.
- The local authority should have a say on PSA and contractual arrangements with oil companies and seek legal advice from international legal consultants knowledgeable in the industry standards to ensure that the interests of the governorate, the population, and Yemen are protected.

- The government of Yemen should implement Law (13) of 2012, the Right to Access Information,⁽¹²³⁾ and based on that should publish consistent up-to-date information regarding oil contracts, revenues and international arbitration cases carried out by the government of Yemen.
 - Any settlements awarded to the Yemeni government in international arbitration should be made public, and the governorate should take part in the settlement in a way that ensures affected communities are duly compensated for damages.
- To remedy the problem of diluted responsibility and accountability, reflected in the multiple environmental committees that conduct inspections in concession sites without coordinating with each other, a technical office that reports to the governor's office directly should be established. The technical office should be responsible for inspecting the field sites, conducting reports, and ensuring that international environmental standards are followed by oil companies and all of their contractors.
- The government of Yemen should work to reinstate its membership in the Extractive Industry Transparency Initiative.

Community and Civil Society:

- Identify civil society organizations that are working on the issue of oil pollution and its environmental, health and social impact and support them in organizing and developing joint action plans on the matter. Expand their knowledge on this issue and on how to mobilize community members affected by oil pollution to demand appropriate compensation for their losses of health, life and livelihoods, if this indeed proves to be the case.
- The local authority in coordination with civil society should provide awareness campaigns through local channels, schools, clinics and public areas, to communities living close to the concession areas to warn them of the danger of handling industrial waste, metal pieces, barrels and chemicals.
- Civil society and local councils should provide residents with information on how to report incidents of pollution or health problems suspected to be associated with the oil companies' operations and to whom.

123) "Law No. 13 for the Year 2012 on the Right to Access Information," Yemeni Parliament, October 10, 2018, <http://yemenparliament.gov.ye/Details?Post=171#images>

***Yasmeen al-Eryani** is director of research at the Sana'a Center for Strategic Studies. Al-Eryani is currently a Ph.D candidate in Social Anthropology in Tampere University in Finland. She has extensively researched Yemen-related topics pertaining to civil society in transition and education in emergencies. She tweets at @YEryani.*

This paper was produced by the Sana'a Center for Strategic Studies with the Oxford Research Group, as part of Reshaping the Process: Yemen program.

OxfordResearchGroup
building bridges for global security

www.oxfordresearchgroup.org.uk



WWW.SANAACENTER.ORG