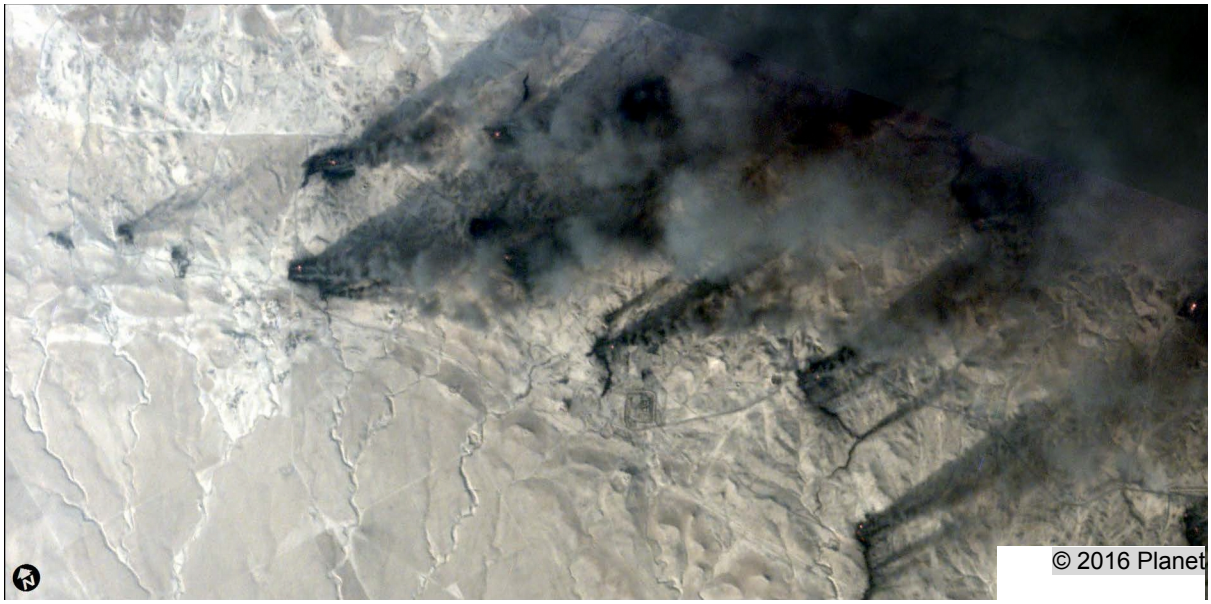

A rapid overview of Environmental and Health Risks Related to Chemical Hazards in the Mosul Humanitarian Response

4 November, 2016

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Executive Summary

This report provides a rapid, not fully exhaustive, overview of the chemical hazards related to ongoing military operations that aim to retake the city of Mosul in Iraq from the Islamic State of Iraq and the Levant. The report is primarily targeted at humanitarian responders and clusters on the ground for consideration and advice in operational decision-making. The analysis focuses on events involving the release of chemical substances, most notably the burning of oil wells and the fire at the Al-Mishraq Sulphur mining and processing complex. The report provides an overview of the major expected short- and long-term environmental and health impacts associated with the recent events and needs to be followed up with a more detailed assessment of implications on health, environment and livelihoods.

The duration of the oil well fires were analysed by the United Nations Institute for Training and Research Operational Satellite Applications Programme (UNITAR-UNOSAT) using fire detection data made available by the NASA Fire Information for Resource Management System. The analysis shows that an initial fire at one or two wells occurred on 8 May 2016, lasting less than one day. Subsequently, on several dates in June small-scale fires burned for durations of less than one day. The current fire complex began on 3 July with daily fire detections occurring until about 12 July. Starting from this date, the number of fire detections increased, and have since then stayed consistently high. Satellite images show that the area around the Al-Qayyarah oil fields has been exposed to oil smoke plumes for around 90 days. Images by the NASA Earth Observatory show the sulphur plume spreading across northern Iraq, Syria and Turkey, where acidic precipitation were reportedly expected over 28-29 October according to meteorological forecasts carried out by the State Meteorological Agency of Turkey.

The burning oil wells, the Al-Mishraq facility fire and other conflict related hazards are impacting the health of the affected population in the short term – where hundreds of people were treated for exposure to chemicals, and millions are exposed to soot and gases from the burning oil wells.

The events are occurring in an already environmentally degraded region, threatened by substantial environmental legacy risk from previous conflicts, coupled with serious desertification and land degradation primarily caused by unsustainable agricultural practices. Nonetheless, the events are expected to cause environmental damage, especially in the short-term and around the most impacted areas of Al-Qayyarah and Al-Mishraq. Acidic gases and precipitation may damage vegetation and increase the acidity of watercourses. Agriculture may be temporarily affected, where the impacts will depend on the soil buffering capacity. A similar fire occurred at the Al-Mishraq facility in 2003 when piles containing sulphur were burning for a month. A subsequent environmental study conducted by the UN Environment Programme concluded that even though the vegetation and crops had been badly damaged by the fire, natural recovery was advancing well two years later. In terms of possible impacts on well water, it should be noted that the nearby wells were found already in 2005 to be unusable due to high sulphate and mineral content.

The burning of oil wells may have a long-lasting effect on the environment, where more detailed studies should be undertaken to compare the extent of burning and contamination occurred now to that of the Kuwaiti oil fires in 1991. Long-term environmental impacts will depend on the amount of oil spilled. In case large amounts has been spilt and/or deposited as lakes or ponds, possible effects on groundwater may occur. Damages to pipelines have not been reported.

The burning oil wells and possible other chemical spills/fires require close monitoring as they evolve, and regular health risk assessment for local areas, as well as in areas where the contamination has spread, in particular by the wind. A health registry of exposed population should be created to monitor and identify long-term health impacts of air pollution. To the extent possible, collection of quantitative data on air pollution should be carried out now by the Iraqi Ministry of Health and Environment including from existing air monitoring stations. Neighbouring countries should also initiate similar monitoring activities.

Environmental impacts will need to be thoroughly assessed as soon as the situation allows. This can be carried out as part of a multi-lateral Post-Conflict Needs Assessment (PCNAs) undertaken by the UN Development Group, the World Bank and the European Commission in collaboration with the Government of Iraq. Alternatively, a standalone Post-Conflict Environmental Assessment (PCEA) may be carried out by the Government of Iraq in collaboration with relevant international partners.

TABLE OF CONTENTS

Cover page: *Smoke plumes from burning oil wells south of Mosul, Iraq (UNOSAT, October 4, 2016)*

1. CONTEXT

The commencement of military operations on 17 October to retake Mosul from the Islamic State of Iraq and the Levant (ISIL) marks a significant escalation of the humanitarian emergency in the country. In anticipation of a crisis defined by large-scale displacement and protection concerns, humanitarian partners are preparing to provide assistance to up to 1 million vulnerable people who may be affected. Environmental pollution from oil wells and chemical plants are adding complexity and danger to a situation which has been described as potentially “the single largest and most complex humanitarian crisis in the world in 2016”. Deliberate as well as unintentional damage to oil wells and chemical facilities has led to environmental and health impacts affecting civilians caught in the conflict, and which have the potential to become drivers of displacement in an already complex displacement dynamic.

This report intends to provide a rapid, not fully exhaustive, overview of the associated chemical hazards and the major expected short- and long-term impacts on health, environment and livelihoods and needs to be followed up with a more detailed assessment. It is primarily targeted at humanitarian responders and clusters on the ground for consideration and advice in operational decision-making.

2. ENVIRONMENTAL HEALTH HAZARDS

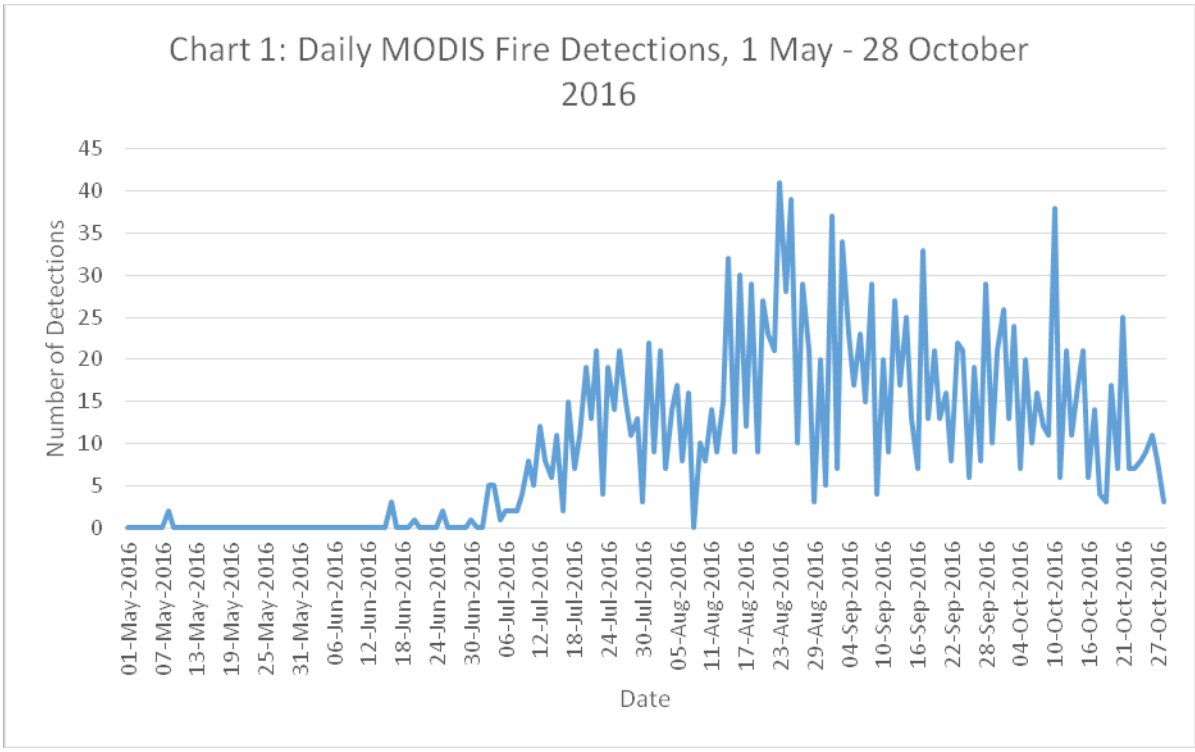
2.1 Burning oil wells

Around twenty oil wells are reported to have been set ablaze by armed groups belonging to ISIL near Al-Qayyarah. On satellite imagery the Al-Qayyarah refinery also appears affected, with about nine of the large storage tanks in the center of the refinery destroyed and burned. Some indications of oil spill are also visible, and other damage may be found as well.The burning oil produces smoke plumes that spread and gradually disperse, depending on factors such as the extent of the damage of the well, the pressure inside the well, the rising hot air, the wind speed and the general meteorological conditions. The smoke is composed of irritant and toxic gases, such as carbon dioxide, sulfur dioxide, oxides of nitrogen, volatile organic hydrocarbons and polycyclic aromatic hydrocarbons, acidic aerosols and particulate matter including small particles of less than 10 microns in diameter (PM_{10} and smaller). Damages to pipelines have not been reported.

UNOSAT is providing satellite imagery analysis support to assess the possible impacts of the Mosul oil fires by assessing the duration of the fires, the extent of the smoke plume generated by the fires, and monitoring daily image acquisitions to note changes in the number of fires. In addition, similar work was done on the long-burning fires at the Alas oil fields east of Baiji and Tikrit as their plumes often mingled with the Mosul fire plumes. These analyses drew from multiple satellite imagery sources including the MODIS and VIIRS sensors aboard US government satellites, the Landsat satellite also operated by the US government, and imagery collected by the private companies Planet and DigitalGlobe.

Fire Duration

To understand the duration of the Mosul oil fires UNOSAT utilized MODIS fire detection data made available by the NASA Fire Information for Resource Management System (FIRMS). MODIS fire detection data is commonly used for fire monitoring and research around the world and is suitable for assessing oil well fires. Notably however, fire detections of oil fires can fluctuate as the thick black smoke produced can obscure the fire itself from the sensor. Analysis of the MODIS fire detection data indicates that an initial fire at one or two wells occurred on 8 May 2016 which lasted less than one day. Subsequently, on 16 June, 20 June, 25 June, and 30 June similar small-scale fires burned for durations of less than one day. On 3 July the current fire complex began with small numbers of daily fire detections occurring until about 12 July, when the number of fire detections increased and fire detections stayed consistently high. These results are illustrated in Chart 1 which shows the number of detections from 1 May until 28 October. Finally, the same method was used on the Alas oil field fires, which indicates that those fires have been ongoing / continuous since at least early January 2016. Media reports suggest that many of the fires started in July and August had been set alight by ISIL militants. Chart 1 shows the fires burning in the immediate vicinity of the Mosul area.



Smoke Plume Extent and Severity

To understand the extent of the smoke plume and the potential severity of its impact across different areas of Iraq, UNOSAT processed and analyzed 99 MODIS satellite images collected between July 18 and October 24, 2016. Given the arid climate of Iraq clouds are relatively rare and thus large numbers of these images could be analyzed to determine which locations experienced more or less time with the plume overhead. The studied area is seen in Picture 1, outlining those areas with a visible plume. Note that as the plume dissipates then areas of thinner smoke are not detected in this process, and thus this analysis indicates only the areas of dense, relatively heavy smoke. The direction of the plume varied greatly over the analysis period due to changing wind directions, but was most often blown in southwest, south, and south-eastern directions. UNOSAT analysis of the 99 images provided a daily map of plume locations, which were then combined into a single dataset indicating areas of most and least plume exposure. These results are provided in Map 1. UNOSAT then used this same dataset to determine how many square kilometres were affected and for how many days, summarized as:

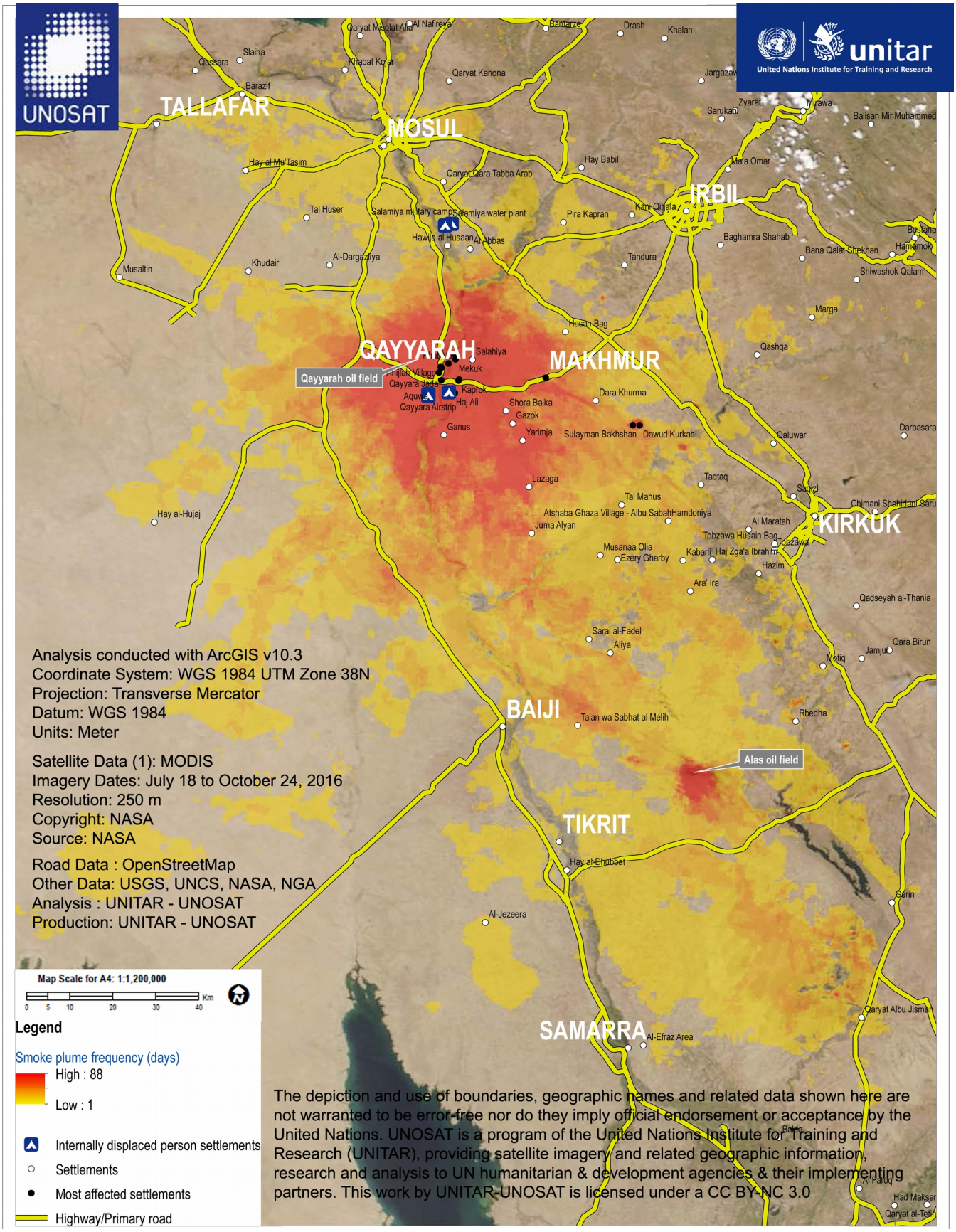
Smoke frequency (days)	***Area Affected (square kilometres)***
1 to 5	20,847
6 to 10	1,698
11 to 20	685
21+	256

In addition, UNOSAT calculated similar exposure by number of days for all towns which were located under the plume at one time or another. A total of 1,733 towns in the PCode dataset for Iraq were affected by smoke for at least one day, and towns affected for 25 days or more are summarized as:

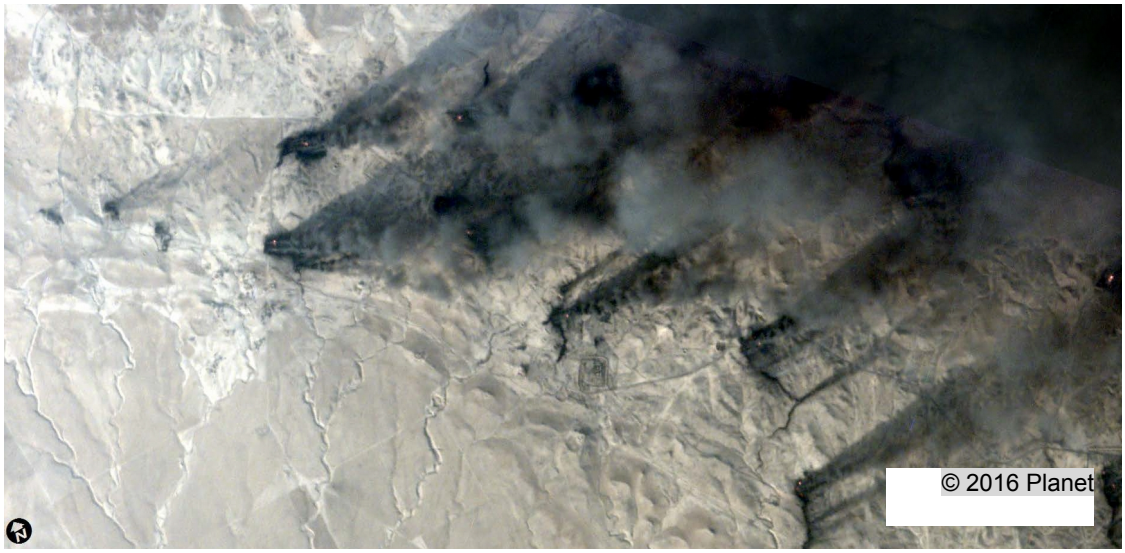
PCode	*Town Name*	*Governorate*	*District*	*Smoke Frequency (Days)*
IQ-P19948	Al-Qayyarah	Ninewa	Mosul	60
IQ-P20416	Karimava	Ninewa	Shikhan	55
IQ-P20183	Rummana	Ninewa	Mosul	48
IQ-P19927	Ahijlah Village	Ninewa	Mosul	47
IQ-P20005	Awsaja Little	Ninewa	Mosul	36
IQ-P14355	Kaprok	Erbil	Makhmur	28
IQ-P14253	En Shahab	Erbil	Makhmur	28
IQ-P14583	Sulayman Bakhshan	Erbil	Makhmur	28
IQ-P14222	Dawud Kurkah	Erbil	Makhmur	27
IQ-P14514	Saidawa	Erbil	Makhmur	25
IQ-P14441	Mekuk	Erbil	Makhmur	25
IQ-P14341	Kabarok	Erbil	Makhmur	25
IQ-P19998	Aquwa	Ninewa	Mosul	25
IQ-P20105	Khabata	Ninewa	Mosul	25

The above table and Picture 1 shows the areas most affected by smoke. Even though the plume was over a specific area or territory it may or may not have directly affected the underlying territory. While areas close to the fires likely saw a lot of direct exposure to particulates in the smoke, areas farther away may not have. Additional analysis was conducted to detect rainfall that may have intersected with the plume and located a few small rain showers totaling 3 mm of rain max in July and August in the area of the Mosul oil well (north and south of Qayyarah)*. Pictures 2-5 show satellite images of the smoke plumes in October 2016.

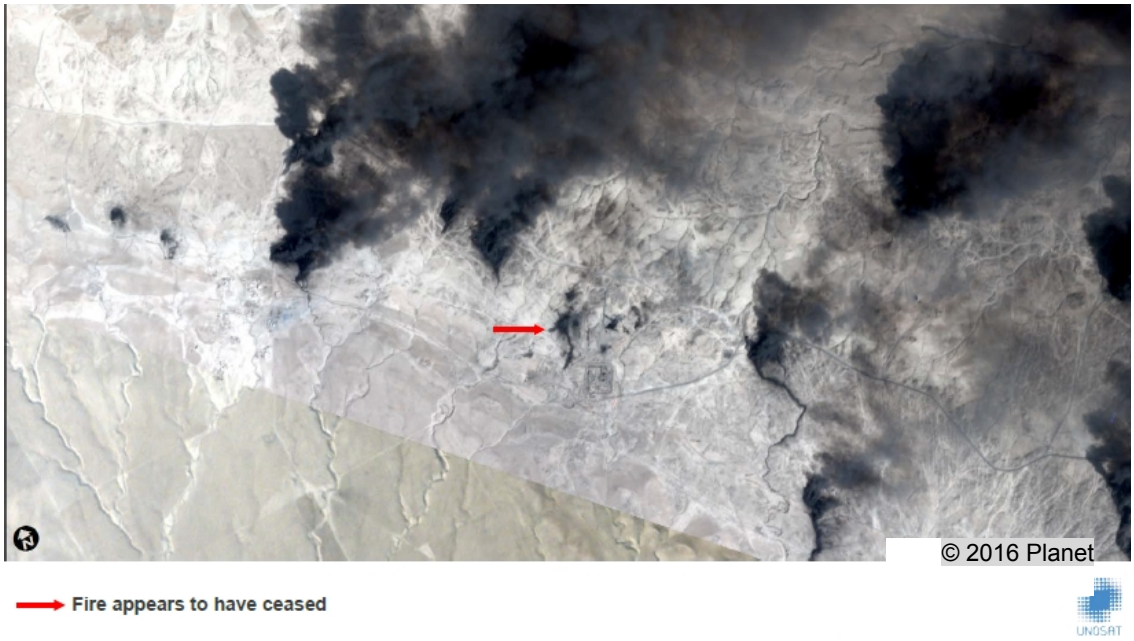
This analysis is available on http://www.unitar.org/unosat/node/44/2491



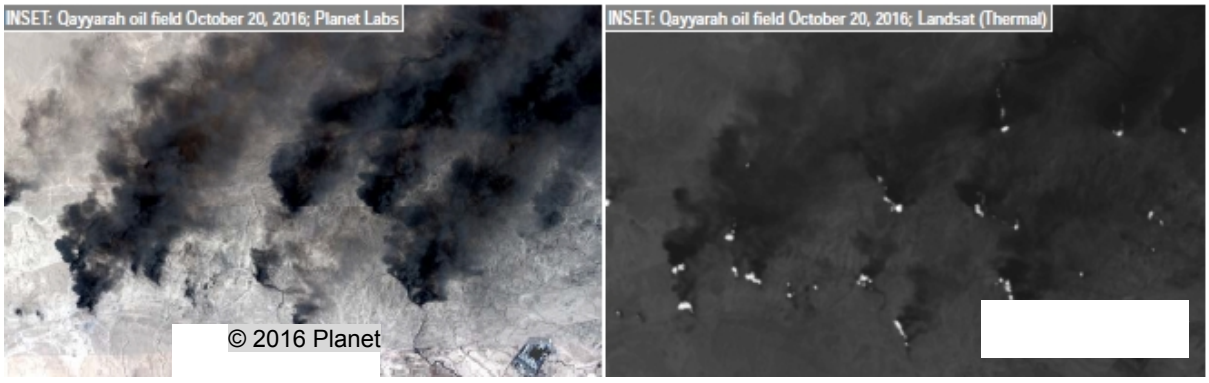
Picture 1. *Smoke plume frequency (days) in the affected areas.*



Picture 2. *Al-Qayyarah oil fields burning, October 4, 2016 (analysis by UNOSAT)*



Picture 3. *Al-Qayyarah oil fields burning, October 20, 2016 (analysis by UNOSAT)*

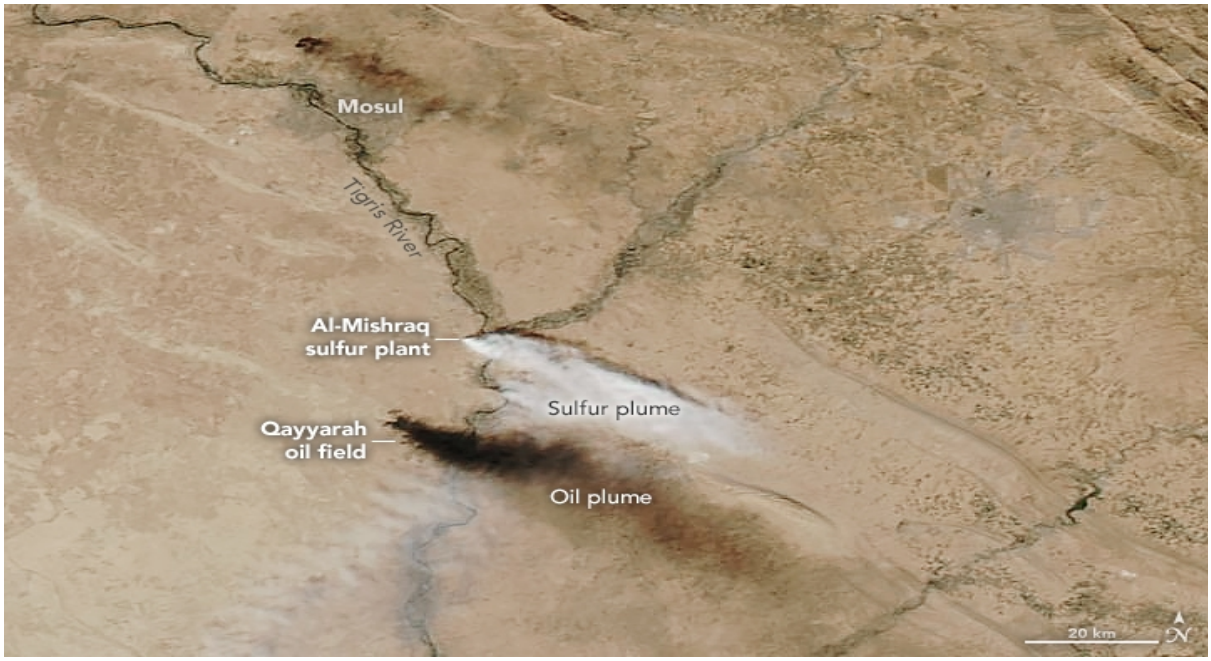


Pictures 4-5. *UNOSAT – Iraq, Ninewa Governorate, Imagery analysis October 26, 2016 / Published Thursday October 27, 2016*

2.2 Sulphur factory fire

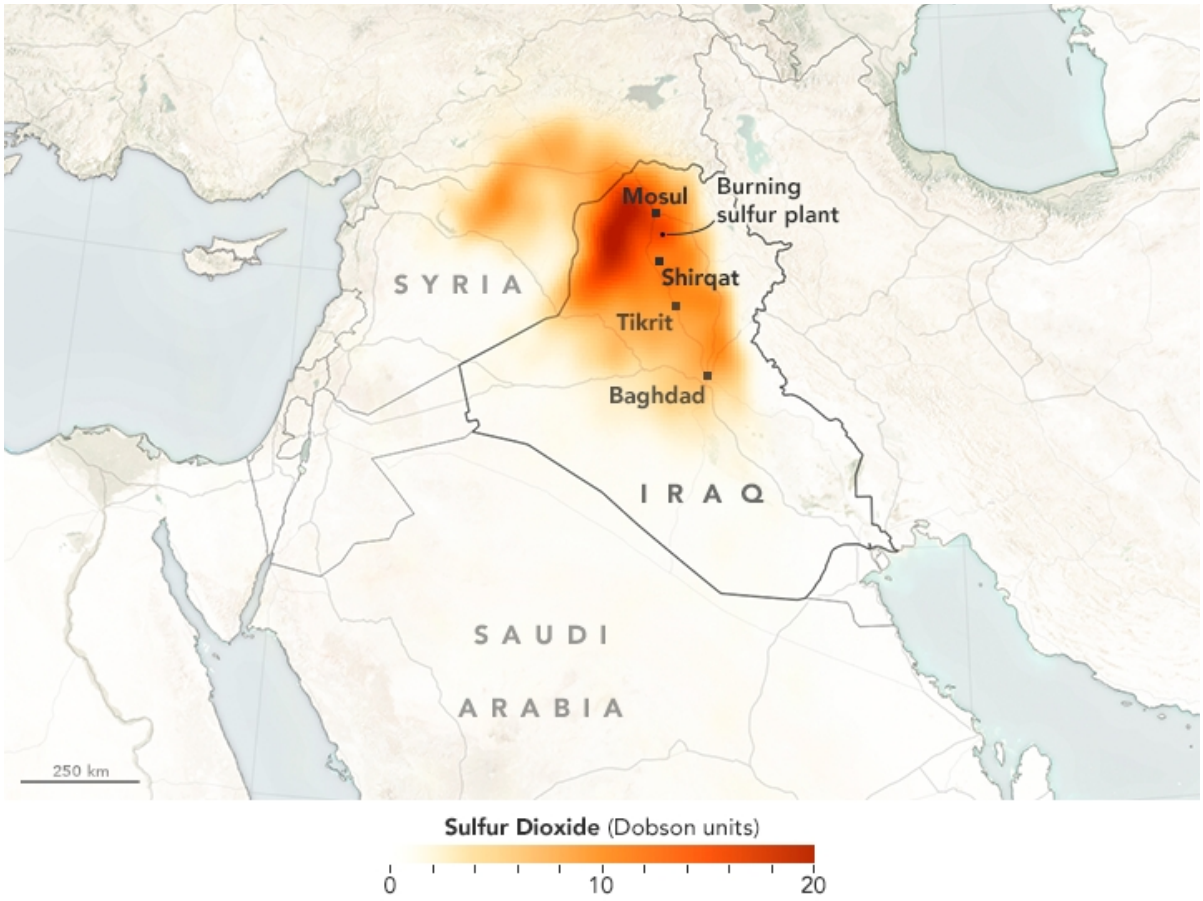
Around 19-20 October, stockpiles of sulphur stored at the Al-Mishraq sulphur mining and processing complex caught fire, leading to a large toxic cloud plume containing sulphur dioxide and sulphur trioxide spreading over dozens of kilometres. The complex is spread over a 17 km^2 area and consists of a sulphur mine, a sulphuric acid plant, an alum (aluminium sulphate) plant and associated facilities for power generation, water treatment and injection, administration and engineering.

On October 20th, 2016, the Moderate Resolution Imaging Spectroradiometer (MODIS), on NASA's Terra and Aqua satellites, first detected the signature of the fire at Al-Mishraq, and by the next day, a plume of white smoke was streaming from the facility. The Ozone Monitoring Instrument on Aura and the Ozone Mapping Profiler Suite (OMPS) on Suomi NPP started observing a large sulphur dioxide plume spreading across northern and central Iraq, which reached higher layers of the atmosphere in the following days.



Picture 6. *NASA Earth Observatory images by Joshua Stevens, using data provided courtesy of the Aura OMI science team and MODIS data from LANCE/EOSDIS Rapid Response.*

The plume coming from the sulphur plant appear to be white-grey (as shown by the NASA's imagery) because it is rich with sulphate aerosols and droplets of sulfuric acid which reflect light, differently from the smoke plumes from the Al-Qayyarah oil field that are black because rich with black carbon and other aerosols that absorb light.



Picture 7. *NASA Earth Observatory images by Joshua Stevens, using data provided courtesy of the Aura OMI science team and MODIS data from [LANCE/EOSDIS Rapid Response](#).*

NASA's satellites are keeping track of the plumes and the above image (Picture 7), taken on October 24th, shows how far the cloud of sulphur dioxide is spreading, including to neighbouring countries Syria and Turkey, as well as the cloud's density (in Dobson units).

On 27 October, following extensive efforts by the Iraqi Government, involving the Ministry of Defence, Civil Defence and Environment, to control the fire, the Iraqi Federal Police announced that the fire at the Al-Mishraq Sulfur Plant had largely been extinguished thus reducing the spread of toxic pollutants across Iraq and its neighbouring countries. Whilst the smoke generated by the site has since decreased significantly, high levels of acidic gases may remain in the surrounding air for some time.

2.3 Other hazards

The deliberate targeting, or accidental damage to, industrial facilities storing and using chemical substances can also cause environmental and health impacts. For instance, textile factories may pose a risk due to the presence of large amounts of solvents and other industrial toxics used in production. Power plants as well as electricity distribution and sewage sites often store hazardous materials, persistent organic pollutants and other chemical products that can constitute a danger. Damage to critical infrastructure can also hamper the functioning of various systems in place to regulate hazardous substance control.

A building (possibly a water treatment plant) west of Baghdad in the Albu Farraj Area of Ramadi was on 23 or 24 October reportedly affected by fighting, leading to an explosion and chlorine gas leak. The explosion and associated chlorine gas leak reportedly killed seven individuals and caused breathing difficulties of low to medium severity to up to 200 people.

The deliberate use of highly toxic chemicals against civilians represents a significant risk to health. In Iraq, increased reports of chemical weapon use by the Islamic State were registered in both 2015 and 2016. Independent and authoritative confirmation of the use of sulphur mustard (a blistering agent that can persist in the environment depending on the temperature) in the Kurdistan regions of Iraq was issued by the Organisation for the Prohibition of Chemical Weapons (OPCW).

Finally, destruction of residential areas and buildings is expected to lead to human health and environmental damage. Crushed building materials contain harmful substances such as asbestos, pulverized cement, household wastes and chemicals which can cause exposure hazards to civilians and people dealing with the rubble. In the wake of the conflict, collapse of environmental governance can further lead to accumulation of solid household, medical and industrial waste, and if not dealt with properly, can result in increased burning of solid waste and resulting environmental health risks, or the outbreak of communicable diseases.

Targeting of weapons/ammunition storage sites in the city can leave a toxic footprint of various chemical substances such as lead and mercury, or rocket propellants, which civilians can be exposed to, or have long-term impact on the environment if these sites are not timely identified and remediated. Destroyed military material such as tanks and armoured vehicles often contains various toxic materials such as PCBs and asbestos. These were in past UNEP assessments in Iraq noted to be of a particular hazard to children using them as playground or scrap metal workers, stripping them of valuable materials.

3. POTENTIAL IMPACTS

3.1 Human health

The immediate health effects of the burning sulphur factory and the oil wells have been reported in the surrounding areas. Between 19-21 October, the Federal Ministry of Health and the Directorate of Health, supported by WHO, treated over 1000 cases of respiratory symptoms and other effects associated with smoke exposures in Qayyarah, Ijhala, and Makhmour primary health care centres.

The clouds caused by burning oil wells and damaged industrial facilities consist of a number of different substances, each causing different health effects. **Irritant gases and acid aerosols** can cause eye, nose and throat irritation, coughing and difficulty breathing. Prolonged exposure can damage the airways and increase the risk of respiratory infections. People with asthma and other chronic respiratory conditions are particularly at risk. **Particulate matter** is a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. Small particles (PM_{10} and smaller) can penetrate deep into the lungs and can aggravate asthma and other respiratory conditions. Prolonged exposure to PM_{10}s and can increase the risk of cardiovascular and respiratory diseases. These substances, together with **polycyclic aromatic hydrocarbons** may increase the risk of lung cancer in the longer term. Other components of the smoke include **volatile organic chemicals**, which can cause dizziness and headache, **and toxic metals** such as lead and mercury. While the immediate pathway of exposure is the air, some of these substances will settle on soil and surface water, or may be carried out of the plume by precipitation (rain/snow) and deposited on the soil and surface water. For this reason, people's health can be affected both by air and water.

Exposure to **sulphur oxides**, such as those released by the fire at the Al-Mishraq facility, causes irritation to the nose, throat and chest resulting in coughing, sneezing, runny nose and tightness of the chest. Exposure to high levels can cause nausea, vomiting, stomach pain and corrosive damage to the airways and lungs. People with asthma are more sensitive to the fumes and are at greater risk of developing bronchospasm even at low levels of exposure. Skin contact may cause stinging, redness and possibly blistering. Eye contact can cause watering, stinging and redness of the eyes. In severe cases damage to the cornea can occur, which may result in permanent injury. Longer term effects may include permanent lung damage and reactive airways dysfunction syndrome.

The Ministry of Environment (now merged with Health) had installed a network of advanced air quality monitoring stations in Iraq around 2011. Some of these may still be functional particularly in the Kurdistan region (e.g. Erbil, Sulmaniya, Dohuk) but also Baghdad. WHO and also UNEP should follow-up with the Ministry if they are collecting and analyzing air quality data. In addition, the Environment Ministry may have mobile stations which they can deploy to conduct measurements. In any case, if a reliable study of the air pollution is to be made, quantitative data need to be collected now. It will be too late post-conflict as was the case in Iraq 2003, Lebanon 2006.

3.2 Environment

The substances released from the burning oil wells and the damaged industrial facilities will impact especially the environment around the Al-Qayyarah oil fields and the Al-Mishraq facility, with possibility of long-term effects. Nearby vegetation, soil and watercourses are exposed to airborne substances, where the impacted area will depend on the meteorological conditions (see above). Some substances, like soot and particles, will deposit on the ground, while others such as sulphur reacts with water vapour in the air forming sulphurous acid, a weak acid which returns to the ground in the form of precipitation. Deposited substances will get into the soil, where the geology of the soil will impact their environmental fate and persistence. Some of these pollutants may fall out in the snow in the approaching winter season. The alkalinity of the soil will also determine its buffering capacity. Some contaminants, like heavy metals, can persist for years - compromising agriculture and harming aquatic life. Studies of past events like the burning of oil wells in Kuwait in 1991, or the sulphur fire in Al-Mishraq in 2003, offer clues as to the expected short- and long-term environmental impacts of the recently occurred incidents.

The burning oil wells in Kuwait in 1991 caused significant environmental impacts – both through the distribution of soot and particles, but also through the spill of significant amounts of oil. According to a NASA report, an estimated one to 1.5 billion barrels of oil were released into the environment. After most of it burned, 25 to 40 million barrels remained spread out across the desert and 11 million barrels washed into the Persian Gulf. When the last one was extinguished in November 1991, about 300 lakes of oil remained. The smoke from the burning wells caused a temporarily drop in the temperature, affecting weather patterns in the Persian Gulf and surrounding regions. Airborne soot and oil fell out of the sky and mixed with sand and gravel to form “tarcrete” across 5 percent of Kuwait's landscape. Subsequent clean-up efforts have removed 21 million barrels of oil from the desert, but an estimated 1 million still remain. Studies showed that vegetation in most of the contaminated areas began recovering by 1995, with some oil lakes solidifying as a result of the dry climate. Oil over time continued to sink into the sand, with possible ensuing consequences for groundwater resources. To estimate the current fires’ impacts on the environment, more detailed studies should be carried out, comparing them to the 1991 events.

The effects from the sulphur fire can be estimated by comparing the incident with one which occurred at the same facility in June 2003. During that time, an estimated 300,000 - 400,000 tons of sulphur burned for about a month. As in the current case, when the pure sulphur stockpiles were set on fire in 2003, satellite image, tracking the plumes, showed the sulphur dioxide cloud dispersing to southeast. Elevated sulphur dioxide concentrations were detected over 200 km away. Moreover, extensive damage was reported at the time, where acidic outfall burned wheat crops and other exposed plants.

A UNEP 2005 study conducted on the hot-spots of Iraq, analyses the possible long term environmental damage from the fire, noting that the most common impact is vegetation dieback, particularly trees. In the absence of vegetation, erosion rates are significantly increased and, dependent upon topography, the area can become stripped of topsoil and effectively barren.

It should be noted that a one-off event such as a fire is an intense, but short-term source of pollution. A study of the contamination around the Al-Mishraq plant (Ibrahim, 2011), showed that short-term damage to vegetation was severe close to the plant, but did not find evidence of widespread or significant long-term damage. The study concludes that the 2003 fire did not damage the environment permanently and also reported natural recovery to have advanced. Even though the leaves and steams exposed to the acid aerosols were damaged at the time of the fire, the plants survived and future crops planted were expected to be largely unaffected.

The 2011 study (Ibrahim, 2011) showed surface water in the area to have a high level of sulphates and carbonates. However, sulphur compounds are a naturally occurring geological phenomenon where some degree of water contamination by sulphur compounds is expected as a natural occurrence. However, the surface water in the immediate vicinity of the sulphuric acid plant and waste piles had pH values between 0.6 to 4.1, indicating a highly acidic, and probably not natural, source. The UNEP 2005 study showed similar results – highly acidic conditions in surface water close to the facility.

The UNEP 2005 study of the Al-Mishraq site also included groundwater monitoring, where five local village wells at a distance of 1 - 5 km from the site were tested. Of these, four were deemed as unusable by the local population due to high sulphate or hydrogen sulphide levels. The study was unable to discern whether the wells became unusable due to the mining conditions or natural conditions. The study did, however, conclude that much of the region’s groundwater was of low quality due to its high mineral content. This shows that any analysis of the fire’s impact on surface and well water should take existing preconditions into account.

3.3 Livelihoods

Since 3 November, rainfalls and associated flooding, in the affected areas are causing additional concern as pollutants are being washed out from polluted sites (run-off) as well as deposited through the rain (wet deposition) on agricultural fields, into the Tigris river, villages, etc. The geography of the landscape, consisting of hills and valleys, as well as the onset of the rainy season aggravate the scale of this concern and necessary precautions will need to be taken to minimize the impacts of rain and associated flooding to reduce the impact of toxic pollutants on livelihoods in the short-, mid- and long-term.

4. INTERNATIONAL RESPONSE

At the request of OCHA Iraq, the Joint UNEP/OCHA Environment Unit (JEU), on 21 October, put responders on the ground in touch with hazardous materials experts who subsequently provided technical advice on the best way forward for dealing with the impacts of the burning oil wells and the fire at Al-Mishraq facility. The JEU has since then been advising humanitarian responders on the ground of the possible environmental and health impacts of the recent events.

WHO continues to assess the health risks posed by the burning fires around Mosul, and is working with national authorities, and partners on the ground to provide health services to those affected by the smoke. In addition, WHO is preparing for the possibility that highly toxic chemicals will be deliberately used during the ongoing military operation around Mosul. WHO has recently conducted a string of advanced training courses for healthcare workers from Dohuk, Erbil, Kirkuk, Ninewa, and Suleimaniya Governorates. The trainings have improved the capacity of healthcare workers to safely treat patients contaminated by highly toxic chemicals. So far, 90 Iraqi medical personnel were trained, including staff treating civilians from the frontlines of the conflict. WHO has also issued six referral hospitals with chemical protective equipment, so that they can function safely while delivering life-saving care to patients exposed to toxic chemicals.

UNOSAT will continue to monitor the status of the Mosul oil fires on daily basis using various images as they become available. MODIS optical images clearly show the plumes when not obstructed by clouds, and are made available twice per day by NASA. Other sources of imagery include Landsat, Planet, and DigitalGlobe which are not collected daily but can provide more detail on the fires and plume status when they are collected. As of 1 November the plumes are still visible.

5. CONCLUSIONS

The burning oil wells, the Al-Mishraq facility fire and the other hazards are impacting the health of the affected population in the short term, with at least some level of short-term environmental damage to be expected. A health registry of the exposed population should be created to monitor and identify long-term health impacts.

Nearby watercourses, vegetation and crops may have been affected by acidic gases and precipitation caused by the sulphur cloud. Comparing to the impacts of a similar fire which occurred in 2003, it is likely that significant negative environmental effects will be limited to the facility surroundings and areas affected most directly by the cloud. Environmental studies conducted by UNEP around Al-Mishraq two years after the previous fire showed advanced natural recovery, most likely due to the soil buffering capacity. In terms of possible impacts on well water, it should be noted that the nearby wells were found already in 2005 to be unusable due to high sulphate and mineral content.

The burning of oil wells may have a long-lasting effect on the environment, where more detailed studies should be undertaken to compare the extent of burning and contamination occurred now to that of the Kuwaiti oil fires in 1991. Long-term environmental impacts will depend on the amount of oil spilled and/or deposited as lakes or ponds, where possible effects on groundwater cannot be excluded.

The burning oil wells and possible other chemical spills/fires require close monitoring as they evolve, and regular health risk assessment for local areas, as well as in areas where the contamination has spread, in particular by the wind. A health registry of exposed population should be created to monitor and identify long-term health impacts of air pollution. To the extent possible, collection of quantitative data on air pollution should be carried out now by the Iraqi Ministry of Health and Environment including from existing air monitoring stations. Neighbouring countries should also initiate similar monitoring activities.

Information on the risks, locations and impact should continue to be disseminated through the clusters for inclusion in response mechanisms, taking into account the concerns and information from various sources, including civil society. Feedback and verification from field partners can be helpful to assess the impact on health and environment and inform and improve awareness of the risks.

In addition to assessing the ongoing impact on human health, post-conflict stabilization efforts in Mosul district will require an understanding of the prospects for people to [return to these areas and] resume their lives and livelihoods. Further environmental studies should be designed to determine the effects on agricultural production and other economic activities that depend on the land and waterways.

6. Sources and additional information

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