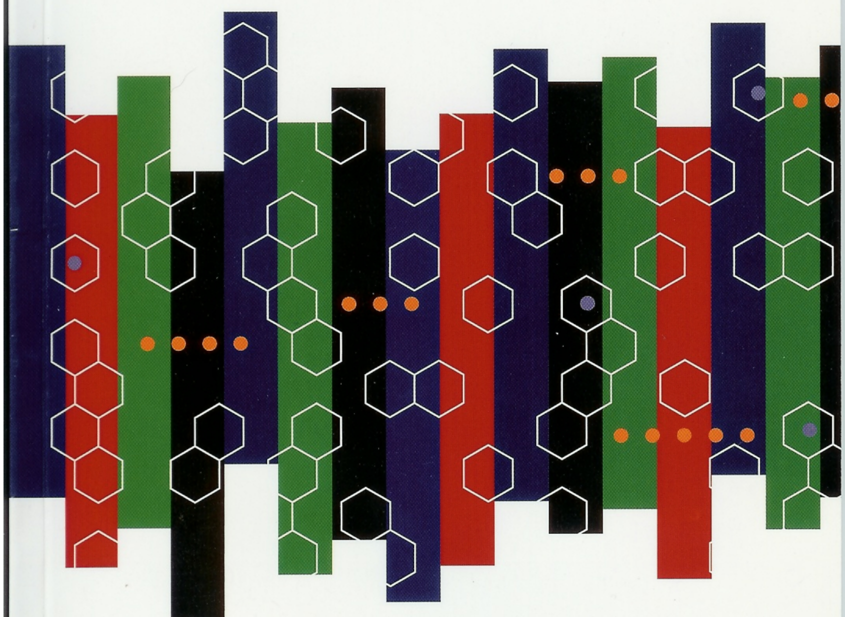
Common Ground on Chemical Risk: Case Studies from the Middle East

Hasan Dweik, Derar Melkawi, Salah Eldin Selim Mohamed, Jean Negreanu, Shlomo Rosenberg, Yair Sharan and Mohammad K. Shiyyab

Edited by Gayle Meyers



Search for Common Ground

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Introduction

Gayle Meyers

The case studies in this book were prepared by members of Search for Common Ground's Middle East Chemical Risks Consortium (CRC)—a group of Egyptian, Israeli, Jordanian, and Palestinian research centers that agreed to reach across political lines and cooperate to address the problem of chemical risks. The CRC has two goals: to improve the capacity of the nations of the Middle East to manage the consequences of chemical incidents, both individually and together, and to build confidence among participating nations. This essay will describe the history of the CRC, analyze the rationale behind its creation, and summarize the lessons learned from the case studies.

History

The CRC was founded by Search for Common Ground (SFCG), a Washington- and Brussels-based nongovernmental organization whose mission is to transform how people and institutions deal with conflict—away from adversarial approaches and toward cooperative solutions. SFCG designs and implements multifaceted programs that aim to resolve conflict and prevent violence. It seeks to help conflicting parties to understand their differences and act on their commonalities.

The CRC grew out of a project on weapons of mass destruction (WMD) in the Middle East. For many years, the SFCG Middle East Security Working Group had discussed the need for arms control in the region. By mid-2001, the dangers of proliferation had escalated with the growing possibility that nuclear, biological, or chemical technology could end up in the hands of unstable regimes, terrorist organizations or other unpredictable non-state actors. It became clear that in the Middle East, few nations are adequately prepared to

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respond to chemical and biological attacks or accidents, and the worsening Palestinian-Israeli conflict had by then nearly extinguished communication among parties in the region.

The working group met in November, 2001, when the attacks on the Pentagon and World Trade Center and the release of anthrax in the U.S. mail brought concerns about terrorism and WMD into sharp focus. Participants in the meeting, who included strategic analysts from across the Middle East, agreed that they all shared a common vulnerability to unconventional attacks and suggested that SFCG design a project to mitigate that vulnerability. A follow-on meeting of subject-matter experts recommended that the project not only confront the threat from biological and chemical weapons, but also build dual-use capabilities to address related civilian concerns. As a result, the CRC and a companion group—the Middle East Consortium on Infectious Disease Surveillance (MECIDS)—were formed.

SFCG convened the CRC for the first time in January, 2003. The Middle Eastern participants included chemists, environmental engineers, and former military personnel. A health and safety manager from the Organization for the Prohibition of Chemical Weapons (OPCW) provided additional expertise. The participants sketched a picture of a Middle East facing a wide spectrum of chemical risks:

- In areas without a strong government structure, agricultural industries use banned pesticides like DDT, and accidents at unregulated factories claim many lives.
- An earthquake fault runs through the region, threatening chemical plants.
- Non-state actors could use chemicals in an attack against civilians, and the prospect of large-scale conflict brings the fear that a missile could hit a chemical storage area or that chemical-tipped missiles could land on populations.

They agreed that chemical risk management is vitally important and worthy of joint cooperation, and that preparing for chemical accidents helps in preparing for deliberate attacks.

As an initial project, each organization in the CRC agreed to write a case study of a local incident and draw lessons learned for chemical emergency response. They met again in June 2003 in Larnaca, Cyprus, and presented the results of the case studies. This book is a compilation of those studies. This project is novel not only because it produced rare cooperation among these four nations, but also because the Middle East is thinly represented in published literature on disasters. For their next project, CRC participants will collaborate on a publication describing how each nation could contribute to responding to a regional incident and envisioning what such regional cooperation would involve.

Why a Chemical Risks Consortium?

The CRC meets two kinds of needs: the need for efficient chemical incident response in the Middle East, and the need to build confidence in this tense region.

Chemical Incident Response

Geography compels these nations to cooperate on chemical risks. Cross border effects are very probably in the region. A single catastrophic chemical accident could release a plume that would affect Israeli, Palestinian, and even more remote Jordanian and Egyptian populations. Even if an incident were contained in one country, neighbors should be able to call upon each other for help, rather than waiting for assistance to arrive from the United States or Europe. Rapid assistance would be especially important in a chemical incident, which would have an immediate effect, unlike a biological attack, which would manifest itself over the course of hours or days. On a chronic basis, pollution from poorly regulated factories can harm the neighboring population. And finally, the threat of an unconventional attack by a non-state actor menaces the entire Middle East.

Confidence Building

The CRC can also be viewed as a confidence-building measure (CBM). CBMs are actions or structures designed to reduce the risk of surprise or misinterpretation of military or political activity. They range from routine advance notification of military maneuvers to verification of arms stocks to the availability of a hotline between heads of state. Within the context of a relationship among hostile states—or states like Israel, Jordan, and Egypt that are technically at peace but harbor significant mistrust—they can include small agreements maintained over time that serve to build up trust. More loosely defined, they can include diplomatic relations, scholarly or cultural exchanges, or other ways in which contact among nations is taken out of the crisis sphere and into the realm of routine.

Confidence-building measures perform four basic functions. The first, increasing transparency, is based on the idea that confidence in the military sphere can be ensured by practical actions that are verifiable and can be properly assessed. It can apply to official civilian as well as military activities. It addresses parties' reluctance to enter into treaties they fear their adversaries will not implement.

The second function, acting as a surrogate for trust, involves bringing in a third entity, in the form of an international legal agreement, a piece of monitoring technology, or a powerful nation. This third party guards against the possibility that the adversaries will renege on their agreements by acting as an enforcer and shifting the balance of power toward cooperation.

The third function of CBMs, routinizing contact among adversaries, enables better evaluation of the adversary's actions, especially in the heated atmosphere of a crisis, while at the same time allowing decision makers or future decision makers to form more sympathetic opinions about each other and to build trust among the individuals involved.

The final function, sending a reassuring message to opposing elites or publics, helps reduce the domestic risks for peacemaking leaders by recasting the enemy in a less threatening mold, and it serves as a moral and psychological guarantee of security.

Scientific and technical cooperation mechanisms like the CRC provide important avenues for routinizng contact among adversaries. A shared professional culture built on objective standards opens the door for scientists to discuss issues of common interest without being diverted by political differences. In face-to-face meetings, individuals replace negative stereotypes with live, generally positive, images of their counterparts. Sustained cooperation on scientific projects is even more powerful as the individuals work together to confront a common problem instead of confronting each other. They, in turn, relay their positive experiences to colleagues back home.

The experience of confidence building will be heightened in the CRC because chemical risk is a sensitive subject in the Middle East, where suspicion about chemical weapons is high. Jordan is a party to the Chemical Weapons Convention, but Egypt has neither signed nor ratified it, and Israel has signed it but not ratified it. Both of the latter two states suspect that the other maintains a weapons program. Increasing transparency about civilian chemical risk management will help build trust. Not only will the parties learn about each other's infrastructure, which corresponds with legitimate civilian uses, but they will benefit from the experience of learning that the other side can share truthful, verifiable information about a sensitive subject.

The Case Studies: Lessons Learned

Each research center participating in the CRC chose a recent case of a local accident involving toxic chemicals. The cases highlight legal, technical, operational, and human factors contributing to the accident and draw lessons applicable in any country. Unlike the notorious 1984 Bhopal chemical factory accident in India, these incidents received relatively little media coverage and almost no publicly available analysis.

The Jordanian paper, prepared by Dr. Derar Melkawi and Major General (ret.) Mohammad Shiyyab, describes a July 1998 incident in which the residents of the Amman west region complained of being supplied with discolored, smelly water. A number of Jordanian government agencies and international consultants investigated the problem and concluded that the taste and odor originated from algae in the water, and that the local water treatment plant's processes and operations were insufficient to deal with the magnitude of the problem.

This case highlights the need for operational flexibility and a good public affairs mechanism. The water treatment plant in question had been running successfully for ten years without incident. Its standard operating procedures of adding a specified mix of chemicals managed routine issues. When the problem developed, however, the taste and odor problems were far greater than any experienced before, and the plant's staff failed to respond quickly enough to avoid the problem that resulted.

The Jordanian authorities also had some problems explaining the situation. The Minister of Water and Irrigation made two conflicting press remarks. These indicated that the water treatment plant staff had failed to react to the problem they faced and were late in shutting down the water supply, claiming that the plant had failed to cope with the problem sufficiently. Ultimately, however, the authorities provided citizens of Amman with clean drinking water from other sources and with the information they needed.

The Palestinian case, written by Dr. Hasan Dweik, focuses on the need for laws and regulations that are properly written and enforced. On October 21, 1999, a fire broke out in a factory that produced gas-filled cigarette lighters in the city of Hebron in the southern West Bank. Fourteen young women were killed. The factory was on the ground floor of a four-story building in a densely populated area. Its owner had no legal permit to operate his factory and did not follow any fire regulations. The factory had no fire exit and only one front door, which was usually closed after the arrival of the workers. The factory also employed 20 boys aged 6-13 years, who worked after school for 50 cents per hour.

At the time of the incident, there was no legislation fully addressing the health and safety of workers at the workplace. Demonstrations broke out in the city of Hebron for a few days after the incident demanding that the law be implemented, that those responsible be tried in court and sentenced, that members of the Municipal Council in the city of Hebron resign, and that existing legislation be more effectively enforced. The result of this "battle for law," as it was called, was an extensive move to process and endorse relevant laws that prevent such an accident from occurring in the future.

The Egyptian paper, by Major General (ret.) Salah Eldin Selim, explains a fire accident that occurred in May 1998, at an Egyptian field petroleum company in the eastern desert, on the shore of the Gulf of Suez. This fire was the result of a lightning strike on a crude-oil processing plant. Other contributing factors to the fire included defects in the ability to detect a fire quickly, a delay in the alarm system, a failure within the firefighting network, and hesitation in calling professional firefighting teams. As a consequence, five degassing, operational, and storage tanks were burned and some firefighters were injured, including two seriously. The result was the closure of the oil production plant due to the devastation caused by the fire, and extensive environmental damage.

The major lesson of this case is the interaction between technical and human factors. If the plant had had preventive measures in place to better protect it from lightning strikes, the tanks would not have caught fire. Such preventive measures could include fixed or floating roofs to protect crude oil storage tanks and proper grounding of processed steel structures. Also critical, however, was the delay in calling the armed forces' firefighting units, which were the best trained and equipped in the area. This decision resulted in greater damage.

The Israeli paper, by Shlomo Rosenberg, Dr. Jean Negreanu, and Dr. Yair Sharan, has a similar lesson. It describes a June 1991 incident in which a cloud of undefined chemical vapor escaped from a chemical plant located in the southern region of Israel, near the town of Ashkelon. During the following hours, many people in nearby towns and in more distant locations (including Palestinians in the Gaza Strip) complained about a foul smell.

The chemical plant (Paz-Chem) was producing a dimethoate-based insecticide named "Rogor." The incident was a result of a runaway chemical reaction that occurred after the reactor was shut down. The result was that a PVC tube connected to the reactor broke down. The cloud that emerged from the plant did not contain active organophosphates, but instead decomposition compounds, which affected the people in close proximity to the plant.

In this case, there were proper procedures in place, but they were not properly carried out. Laboratory findings that gave early warning of a problem with the chemical being produced were reported to the production manager, who considered them insignificant and therefore did not stop production. A faulty temperature gauge was ignored. Another factor that impeded the effective preventive measures from being carried out was the weak relationship among relevant managerial actors.

Conclusion

These cases suggest some fruitful areas for cooperation on chemical risks in the Middle East, which could be carried out through the CRC.

With its focus on legal structures, the Palestinian case makes an explicit link between the conflict in the region and the danger of chemical incidents. An independent and fully functioning Palestinian state could have enforced health and safety laws. Publicizing this side effect of occupation can lend urgency to the search for peace. The case also shows the importance of maintaining cooperation between Palestinian and Israeli authorities, both of whom sent fire brigades that worked together to extinguish the fire.

In the Jordanian case, authorities sought advice from the government of Norway and the World Health Organization. They also consulted with their Israeli neighbors. Because the incident evolved slowly, there was time to involve European experts, so the nations' proximity was not an issue. On the other hand, Jordanian authorities had to deal with popular perception that Israel was responsible for injecting polluted water into the Jordanian system. Visible cooperation between Israeli and Jordanian water experts might have served as a confidence-building measure by routinizing contact and increasing transparency,

but the presence of third-party experts would also have been essential to provide an impartial judgment on the source of the pollution. Publishing detailed information about this incident, as this publication does, also helps increase transparency.

In the Egyptian, Israeli, and Palestinian cases, local response capabilities were overwhelmed, and national police or military units were called in to assist. Human error was also an important factor in all four cases, with the most common error being poor coordination among different players or reluctance to call upon appropriate experts. The widespread need for better training suggests that this could be a useful area for future multinational cooperation.

The Egyptians, Israelis, Jordanians, and Palestinians in the CRC have begun a process of information sharing and confidence building. Their ideas will inform a vision of a safer, more cooperative Middle East.

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I would like to thank the many people who made this publication possible. First and foremost, I am grateful to the members of the Chemical Risks Consortium for having the courage to come together, to exchange ideas frankly, and to take a risk on Search for Common Ground—all while maintaining a shared vision of a more secure future in the Middle East. I give my special thanks to John Good for helping the group to meet its objectives and helping me to grow as a leader. This book could not have been published without the partnership and financial support of NTI, the Compton Foundation, and the Ploughshares Fund. Particular thanks are due to Joan Rohlfing of NTI.

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—Gayle Meyers, Editor

Participating Institutions

The Cooperative Monitoring Center (CMC) @ Amman was established in 2002 at Jordan's Royal Scientific Society and officially inaugurated on October, 2003. The center aims at building regional cooperative activities through sponsoring workshops and seminars to address particular security issues as they relate to the Middle East. The CMC is a forum for regional experts to explore jointly ways that technology can improve regional security and enhance confidence among states. CMC @ Amman is a partner of the CMC operating at Sandia National Laboratories, Albuquerque, New Mexico, USA.

Al-Quds University is a Palestinian university that is situated in East Jerusalem. It has eleven faculties, including Science and Technology, Arts and Humanities, Law, Engineering, Islamic Studies, Medicine, Pharmacy, Dentistry, Public Health, and others. The university serves the Palestinian community and offers bachelor's and master's degrees in more than thirty disciplines. The university serves more than 6500 students with a staff of more than 700, including academic and nonacademic personnel. The university is involved in research and encourages cooperation with regional and international universities and research centers. It has established strong ties with universities in the US, Germany, France, Italy, Spain, Belgium and had funding for collaboration in research from MERC (USA), DFG (Germany), INCO (Europe), and others. The university encourages gender studies and provides many services to Palestinian institutions and to the community as a whole, to promote growth and development.

The Interdisciplinary Center for Technology Analysis and Forecasting (ICTAF) is a leading Israeli institute in technology forecasting, foresight, assessment and long-term planning, and is very active in the international community. The multidisciplinary center taps the expertise of world-class scientists at Tel Aviv University and other well-known research establishments to create a core body of researchers with unrivaled knowledge in a diverse range of fields in exact sciences and engineering, geography, economics, education and social sciences, information technology and communications. ICTAF functions as a think-tank, working alongside its governmental or business clients to produce far-reaching conclusions that are drawn from a unique blend of academic research and market know-how. In recent years, ICTAF has undertaken special activities in the fields of security and civil defense. These include studies on emerging technologies and the future battlefield, issues in future terrorism, threat analysis, and hazard evaluation. Projects deal with the preparation of the population for emergency situations in war and peace. ICTAF cooperates with partner centers in the European Union and the United States.

The National Center for Middle East Studies (NCMES) is the first privately owned and controlled research center in Egypt. However, it exists to meet Egyptian national interests and needs and promote regional peace and security. NCMES is analyzing current events, working to develop sound predictions of future developments in Egypt and the Middle East and endeavoring to influence changes at the regional and international levels. This think-tank has a wealth of knowledgeable and experienced former government officials, intellectuals and businessmen in its organizational structure, staff and as consultants. The NCMES is active in all fields of the second-track efforts to help establish peace and security through regional cooperation efforts in the Middle East.

Case Study One

Jordanian Case Study: Zai Water Treatment Plant, 1998

Dr. Derar Melkawi and Major General (ret.) Mohammad K. Shiyyab

Introduction

This paper has been prepared to explain a July 1998 incident in which the residents of the Amman west region complained of being supplied with discolored, smelly, and odorous water. The water was supplied from the Dabouq water reservoir, which receives its water from the Zai Water Treatment Plant (WTP). The Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ) treated the matter seriously and stopped the supply of water to all users. An investigation committee was formed to investigate the causes of the pollution, with assistance from the World Health Organization (WHO) and the U.S. Agency for International Development (USAID). These reports, however, were not made available to the public, as the matter was considered to be very delicate.

The Ministry of Health (MOH) announced precautionary measures, suggesting that citizens boil their water before use. Despite these actions the problem persisted through July and well into August. A number of Jordanian government agencies and international consultants investigated the problem and concluded that the taste and odor originated from algae in the water, and that the treatment plant processes and operations were insufficient to deal with the magnitude of the problem.

Dr. Melkawi holds a B.Sc. in Safety from Embry-Riddle Aeronautical University, and received his Ph.D. in Modern History. Dr. Melkawi has held many Military Command posts, and was Commander of the Royal Squadron. In 1991, he retired as an Air Force Brigadier General.
Major General Shiyyab is the head of the Jordanian Royal Scientific Society's Department for Disarmament and Security Studies and the Cooperative Monitoring Center at Amman and has served as Deputy Commander in the Royal Jordanian Air Force. Since retirement, General Shiyyab has been actively involved in regional security studies and has participated in numerous conferences, workshops and research projects relating to the Middle East peace process.

Investigations were initiated to determine the source of the problem and identified live nematodes in the raw water and dead ones in the treated water. The nematodes were and are still likely to be originating from the Yarmouk River and could also be developing in silt and organic deposits in the bottom of the King Abdullah Canal (KAC), which supplies the Zai WTP. It was also believed that they could have been breeding in the plant's filters, and in wet weather could be washed from the soil into the canal.

On 19 July 1998, spokesmen from MWI and MOH confirmed to the Petra News Agency (PNA) that the water supplied to citizens from the Dabouq was drinkable. The causes of the recent scare had still not been identified, yet they further confirmed that laboratories had proved the water suitable for drinking, but still suggested, as a precautionary measure that the water be boiled for one minute before use.

Acronyms

MWI	Ministry of Water and Irrigation
MOH	Ministry of Health
Zai WTP	Zai Water Treatment Plant
KAC	King Abdullah Canal
WAJ	Water Authority of Jordan
JWSP	Jordanian Water Strategy and Policies
MCM/Yr	Million Cubic Meters Per Year
SWTP	Samra Wastewater Treatment Plant
DWR	Dabouq Water Reservoir
WHO	World Health Organization
PAC	Powdered Activated Carbon
CS	Caustic Soda
RSS	Royal Scientific Society
EPA	US Environmental Protection Agency

Background

The Hashemite Kingdom of Jordan is located to the east of the River Jordan. It has a number of variable topographical features. A mountain range runs through the country from north to south, and the ground slopes gently towards the eastern desert and steeply towards the Jordan Rift Valley. This valley extends from Lake Tiberias to the Red Sea at Aqaba, at a ground elevation of 220 meters below sea level. At about 120 kilometers south of Tiberias is the Dead Sea, which is approximately 405 meters below sea level. The Southern Ghore and Wadi Araba form the southern part of the Rift Valley. To the south of Aqaba, there is 25 kilometers of which stretches along the northern shores of the Aqaba Gulf.

The highland areas in the summer can reach maximum temperatures on average of 32°C (90°F), and 38°C (100°F) for the Jordan Valley and eastern desert. Highland and desert areas in the winter have temperatures that average between 14 –17°C (57-63°F), and 21°C (70°F) in the Jordan Valley. The highland and desert areas in the winter can reach minimum temperatures on average of 1-4°C (34-39°F), with occasional snowfall, and a minimum of 8°C (46°F) in the Jordan Valley. Jordan's population was 5.2 million in 2000, with a growth rate of 2.8%. Approximately 91% of the population lives in the northwest region of the country, and 52% live in the Amman and Zarka area.

The Water Authority of Jordan (WAJ) was established under Law 18-1988 as an autonomous corporate body with financial and administrative independence and responsibility for water and sewage systems, as well as other related projects in Jordan.

Aim

The aim of this paper is to present the facts and actions that were related to the chemical incident and identify the remedial action taken to prevent any similar incidents occurring in the future.

Water Situation in Jordan[I]

The renewable water resource in Jordan is estimated at about 775 million cubic meters per year (MCM/Yr). This includes 275 MCM/Yr of ground water, and 692 MCM/Yr of surface water, of which 72% can be developed economically. An additional 140 MCM/yr comes from fossil aquifers and a further 50 MCM/Yr is expected to be accessible for urban uses after desalination. The following table shows the projected supply, demand and deficit of water in Jordan:

Year	Supply	Demand	Deficit(MCM/Yr)
1998	857	1.205	(348)
2005	1.042	1.321	(279)
2010	1.250	1.436	(186)
2015	1.283	1.536	(254)
2020	1.287	1.647	(360)

Jordan's Water Strategy and Policies (JWS)[II]

The Ministry of Water and Irrigation (MWI) issued the JWS Document 10-1997, which provided the foundation and initiative to formally develop policies addressing specific issues facing Jordan's water sector. Four policies that have been developed are:

- Ground Water Management (GWM).
- Irrigation Water (IW).
- Utility Water (UW).
- Wastewater Management (WM).

The water policy's objectives are to outline in detail the statements contained in the JWSP, and set out the Jordanian Government's intentions concerning groundwater management. The aims focus on the development of water resources, its protection, management, and measures needed to bring the annual extraction of water from various renewable aquifers to a sustainable rate.

Water Resources

Water sources in Jordan consist of the following:

1. **Surface Water.** Surface water can be defined as water, which flows permanently in rivers, springs and flood flows. Permanent water flow in rivers, valleys and springs varies monthly. It is the quantity of and duration of rainfall that contributes directly to the quantity of ground water. Surface water resources average about 693 MCM/yr and are distributed unevenly in 15 basins, with high inter-seasonal and inter-annual variations. The collective long-term average base flow for all basins is approximately 359 MCM/Yr, and the flood flow is estimated at 334 MCM/Yr.
   a. The Yarmouk River Basin is Jordan's greatest source of surface water and amounts to approximately 40% of the annual total. This includes water flowing from Syrian territories within the Yarmouk Basin. The Yarmouk River is a major tributary of the King Abdullah Canal, which is considered to be the backbone of agricultural development in the Jordan Valley.
   b. Other surface water resources include the Zarka River and several wadis,[iii] where treated wastewater from As Samra Wastewater Treatment Plant (SWTP) and other treatment plants serves the Amman and Zarka regions. To date about 300 MCM/Yr of surface water has been developed for irrigation, municipal and industrial use. Full development has been impeded by regional considerations, related riparian rights of the Yarmouk River, and the high costs of developing and transporting the remaining sources of water, which are estimated at $11 per cubic meter.
   c. Priority has been given to the construction of dams and irrigation projects in the Jordan Rift Valley in order to maximize the utilization of its water resources before it is discharged to the Dead Sea or the Jordan River.
2. **Ground Water.** Ground water is considered to be the major, and in some areas of Jordan, the only water resource. There are eleven renewable ground water reservoirs in Jordan with a total sustainable yield of 275 MCM/Yr. Sustainable yield varies from one aquifer to another.[iv] Ground water can be divided into two types:
   a. Renewable groundwater resources. This is the quantity of water that percolates to aquifers through pores or cracks in rock formations. This water quantity has an annual average that depends on the annual rainfall, and on the recharge surface area of the aquifer. Thus water abstraction from an aquifer has a direct or indirect effect on the natural discharge from that aquifer, including the spring flow. The long-term yield of renewable groundwater resources has been estimated at 275 MCM/Yr. Some of these renewable groundwater resources are presently being exploited to their maximum capacity and in some cases beyond the safe yield. Overexploitation of groundwater aquifers, beyond their annual potential renewable quantities, has and will contribute significantly to the degradation of ground water quality in the exploited aquifers, and endangers the sustainability of these resources for future use.
   b. Nonrenewable groundwater resources. This is the water that is stored in aquifers inside the earth, and is sometimes found under renewable groundwater aquifers. The volume of this water depends on the thickness and storage capacity of the ground layer in which it is found, and on the horizontal layout of that layer. The main nonrenewable groundwater resource in Jordan exists in the Disi aquifer in the south, with a safe yield of 125 MCM/Yr for 50 years. Other nonrenewable groundwater resources are estimated at an annual safe yield of 18 MCM/Yr.
3. **Wastewater.** Treated wastewater is generated at 17 wastewater treatment plants, and is an important component of Jordan's resources. Due to the topography and the concentration of urban population above the Jordan Valley escarpment, the majority of treated wastewater is discharged into various watercourses flowing into the Jordan Valley, where it is used for irrigation. About 70 MCM/Yr of treated wastewater was discharged in 1999 in the watercourses or used directly for irrigation. As the volume of water used by Jordan's municipal and industrial sector increases, wastewater volumes will increase. By the year 2020, it is expected that the volume of treated wastewater available will amount to 230 MCM/Yr and will constitute a significant portion of the total irrigation demand and hence supplement the demand on renewable groundwater resources. Thus, treated wastewater is considered an essential element in Jordan's water strategy.

Water Quality and Environment

Jordan has adopted the Jordan Drinking Water specification #286. This is based on international water quality standards and guideline values developed by the WHO, United States Environment Protection Agency (EPA) and others. These standards are often stringent and are based on the worst-case assumptions, which may not be relevant to local conditions, or even affordable in some cases.
Jordan has witnessed some water quality deterioration during the past two decades due to various causes such as industrial pollution, overuse of agrochemicals, drainage water, over pumping of aquifers, and others.

Water Management in Jordan

Resource Management. The MWI has adopted an integrated approach to water resource management. Enhanced supply measures will be adopted for surface waters (e.g. surface /subsurface storage, reducing evaporation, seepage losses, and protection of water quality). Ground water abstractions will be controlled and reduced to within a safe yield of the aquifers and enforcement will be strengthened. Wastewater will be collected, and treated wastewater will comply with national standards so it can be used for agriculture and ground water aquifer recharge. A wastewater master plan will be developed for un-served areas of the country. The potential technical and economical feasibility of developing brackish ground water resources is continuing to be assessed throughout Jordan.

Wastewater Management. The WAJ has adopted a wastewater management policy, which addresses wastewater as a water resource and includes its development, management, collection, treatment, reuse and regulation.

This policy addresses many topics such as resource development, resource management, wastewater collection, reuse of treated effluent and sludge, pricing, legislation, institutional arrangements, standards, regulations, quality assurance, public sector participation, human resource development and finally, public awareness.

Water System Service Levels

Jordan's existing water distribution system and services are being improved and expanded. This improvement will include technical support and management. Old and damaged supply and distribution systems will be rehabilitated, and inadequacies will be corrected. Service issues include:

- Maintaining water quality in the distribution network.
- Frequency of water supply delivery to customers.
- Response time for repair of network leakage, etc.
- Reduction in waiting times for water and wastewater connections.
- Reduction in waiting time for resolution of customer complaints.

Water Supply Problems in Jordan

Within Jordan the areas that supply water for the country are scattered, which results in high costs for transfer systems in order to transport the water from one region to another. These long distances between supply locations can be up to 100 kilometers apart and therefore pipelines, pumping systems and electrical networks are required, which are costly. Deep-water aquifers can also reach depths of 300 meters, which causes problems by incurring high costs when drilling water wells. Consequently there is often a low productivity of water, which reduces drastically the supply of water being extracted from the sources.

Jordan also has difficult topography, which includes areas that are elevated 1000 meters above the mean sea level, as well as areas that are far below sea level. There are also rapid changes in the population density in certain regions, which can overload the water supply network. Consequently there is a continuous need for the renewal of water supply systems in order to cope with these changes and the growing demand on water.

Water Pollution

Water contamination can be defined as "the contamination of water by foreign matters such as microorganisms, chemicals, and industrial wastes, or sewage." Such contamination deteriorates the quality of the water and renders it unfit for use. Water pollution sources can be classified as:

1. **Municipal.** Municipal water pollution consists of wastewater from homes and commercial establishments.
2. **Industrial.** Industrial wastewater differs within and among industries. The impact of the industrial discharge depends on their collective characteristics such as biochemical oxygen demand, the amount of suspended solids, and the amount of specific organic and inorganic substances.
3. **Agricultural.** Agricultural contamination is the sediment from the erosion of cropland and the compounds of phosphorus and nitrogen that originate partly in animal wastes and commercial fertilizers. It also includes commercial livestock and poultry farming as a source of many organic and inorganic pollutants of surface and ground water.

Water Treatment

Water treatment is one of the ways of converting surface and ground water into drinking water. The Zai Water Treatment Plant (WTP) is the only water treatment plant in Jordan, and there are only six distillation plants for ground water treatment, which are scattered across the country.

The Incident

Issue

The Zai Water Treatment Plant's (Zai WTP) failure to produce drinkable water for the citizens of Amman and its supplying them water that was odorous and contaminated with algae.

Zai Water Treatment Plant (Zai WTP)

The Zai WTP is the only water treatment plant within Jordan, and is considered to be the main component of the Jordan Domestic Water Supply Project, constructed during the 1982–1985.

Location

The plant is located in the Zai region on the eastern heights near the city of Salt.[v]

Plant Objectives

The aim of the Zai WTP is to produce water that is chemically and bacteriologically safe for human consumption. The treated water should be aesthetically acceptable to the consumer and free from apparent turbidity, color, odor, and objectionable taste. The quality of produced water pumped from the Zai WTP should comply with Jordan's Drinking Water Specification #286-2001,[vi] Jordan's Specification #300/1980 and the World Health Organization (WHO) Drinking Water Directives and Regulations.

Zai WTP Water Sources

Raw water is conveyed to the Zai WTP through KAC[vii] and from the intake of the Pumping Station (PS) at Deir Alla in the Jordan Valley. The canal conveys water from:

1. The Yarmouk River[viii]
2. Wadi El-Arab Dam[ix]
3. Al Mukhaibeh well[x]
4. Lake Tiberias[xi], and
5. Ain Hazier, Al-Sharieah and a few other water springs and valleys

The physical treatment process consists of treatment by Clo2, rapid mixing, flocculation, sedimentation, intermediate chlorination, filtration, post chlorination, filters backwash system, metering, chemical feed systems, pumping units and controls.

Conveyance System

1. King Abdullah Canal Conveyance system conveys raw water from many sources and extends from the Yarmouk River in the north to the intake station at Deir-Alla (Sketch-1).
2. Deir-Alla – The Zai WTP Dabouq Conveyance System conveys raw water from the intake system in Deir Alla to Zai WTP, and treated water from the Zai WTP to the Dabouq Water Reservoir (Sketch-2).

Plant Design

Zai WTP has a nominal design capacity of 45 MCM/Yr (123.000 M^3/day), and a hydraulic capacity of 130% of its nominal design.[xii] The water is diverted from the KAC at Deir Alla, where it is screened, and then conveyed through a series of five pump stations, balancing tanks and pipelines to the Zai WTP. The treated water is then pumped to the Dabouq reservoir and from there conveyed by gravity into the city. This overall conveyance and treatment system is shown on the Schematic Diagram of the Deir Alla-Zai-Conveyance System (Sketch-2).

System Description

From the Zai WTP, the treated water proceeds through pump station 5, through a 1,200mm diameter pipe and on to the Dabouq (Terminal) reservoir. Water is then transmitted from the Dabouq reservoir via a 900mm pipe and then pumped into the Muntazah reservoir from where it flows by gravity.

The water in this canal is slow moving, and therefore the canal tends to accumulate silts, mud, and organic matter on its floor. This accumulation, combined with the long detention time and exposure to sunlight, promulgates algae growth. In order to reduce this algae growth, the addition of ferric chloride to the raw water at the head of the open canal has been initiated to precipitate out phosphorous in the water.

Phosphorous is one of the chemicals that enhance the growth of algae. The conveyance and treatment system is shown graphically in sketch-2. The balancing tanks at pump stations 1, 2, 3 and 4 are open to the atmosphere, and they float on the system; that is, the water is not routed through them. The water level simply rises and falls within them, depending on the imbalance between the water delivered and water pumped.

Consequently, the water in these tanks can stagnate and grow algae. This can result in slugs of water loaded with algae having a potential algae-secreted taste with odorous compounds entering the conveyance system and the Zai WTP. To minimize this algae-laden water entering the conveyance system and the Zai WTP, the operators regularly flush the water out via the reservoir overflows.

Water treatment processes are conventional and consist of:

1. Flow balancing and control.
2. Mechanical rapid mixers and flocculators for chemical coagulation and flocculation.
3. Rectangular and horizontal flow type sedimentation basins.
4. Dual-media rapid gravity filters.
5. Two-compartment treated water clear-wells.

Chemicals used include:

1. Potassium permanganate for pre-oxidation and as an aid in taste and odor control.
2. Powdered activated carbon (PAC) as the primary chemical for taste and odor control.
3. Aluminum sulfate (alum) as the primary coagulant.
4. Cationic polyelectrolyte (polymer) as a coagulant aid.
5. Anionic polymer as a flocculation aid; and chlorine to control aquatic growth, contribute to the control of taste and odor, and function as the primary disinfectant.

Provision was also included in the original design to add sodium hydroxide (caustic soda), but this chemical was found not to be needed and was never used. Provision was also made in the design for a spare chemical, which has never been used. The pH of the raw water is normally greater than 8.0. This is well above the optimum pH for alum coagulant. The pH of the water leaving the plant was 7 plus. This indicates that excess alum was being used to depress the pH closer to the optimum value. The anionic polymer had been relocated from the settled water application point to the last stage of flocculation to aid in the aggregation of particles.

Some experts did not recommend an increase to the dosage of chemicals used at the Zai WTP, with the exception of the PAC dose range. They agreed upon the need to increase the capacity of the PAC feeders and slurry pumps. The dosing capacities of the potassium permanganate, chlorine, and polymer feeders were adequate.

MWI and WAJ experts considered taking the Israeli approach to water treatment, including their pre-treatment methods. Israel's main water source is Lake Tiberias. They pump the water into a canal, which is then discharged into a large open reservoir. As the water enters the reservoir, a coagulant and an acid are added, and hydraulic flocculation follows. The water then traverses the reservoir, which is in fact a large sedimentation basin. At this point, other than the addition of chlorine, the water receives no further treatment.

The Israelis have conducted pilot plant studies and now plan to add ozonation and filters after the water has been in the settling reservoir basin. In effect, apart from the addition of ozone, the treatment process is the same as that used at the Zai WTP. In fact, the pretreatment at the Zai WTP is a more controlled and effective system than the Israeli pre-treatment system. The more concentrated the treatment processes are, the more manageable, effective, and efficient they will be. To diversify treatment processes complicates management, communication, and the control of the overall treatment process.

Potential Causes for the Taste, Odor and Nematode Problems[xiii]

The quality of the raw water sources and the warmer summer temperatures in early July 1998 initiated the taste and odor problems. Algae in the raw water sources, with the conveyance systems promoting their further development, along with the inability of the Zai WTP management and operators to treat the water at full plant capacity, was due to inexperience, and caused primarily by insufficient PAC metering capacity.

The taste and odor problems were far greater than any experienced before, but the plant's staff failed to respond quickly enough to avoid the catastrophe that resulted.

The plant had been running successfully for 10 years without an incident like this. At no time was more than 10 milligrams per liter (mg/L) of PAC needed. However, in this incident, regulations required that water production had to be cut back to allow the existing feeders to add 60mg/L of PAC and did not go into detail as to how this could be implemented. However, each of the two PAC volumetric feeders had been rated at 2.7 m3/d – about 10mg/L at the design flow of 123,000 m3/d. The PAC feeders therefore cannot feed PAC in excess of about 10mg/L at the design flow.[xiv] The plant had previously controlled taste and odor in the raw water (in 1997, for example) by using an average of only 10.2 mg/L of PAC, plus 10.3 mg/L of potassium permanganate and 2.8 mg/L of chlorine.

In one way, this incident did have the benefit of identifying nematodes as a future issue. Now that nematodes have been recognized as being present in the raw water and posing a potential health problem, they must be considered in all plant modifications to ensure their inactivation and removal.

The multiple water sources supplying raw water to the Zai WTP contained algae and nematodes. This is something that cannot be easily controlled or economically addressed. The scope of work relating to this incident is limited to the Deir Alla - Zai WTP – Water Conveyance System. However, the fact that the raw water sources do not contain algae and nematodes must be assumed as a given, and their impact on the treatment plant minimized, by limiting their growth in the conveyance systems. This is because the water in the KAC is primarily for irrigation purposes and the canal is only used to store water.

The water velocity in the canal is often slow causing silt, mud, and organic matter to accumulate on the canal floor. This then becomes a potential breeding ground for nematodes and a further source of bad taste and odor. Adding ferric chloride to precipitate out phosphorous, as is currently practiced, can actually exacerbate the situation. These algae blooms could therefore have the potential to cause severe taste and odor problems. Similarly, the resuspension of decaying organic deposits due to increased water velocities, or other reasons, could further add to the taste and odor problems with the water and the resuspended nutrients could encourage algae blooms.

The contributing factors for an algae bloom are complex. They include the correct combination of elements that contribute to an algal bloom, nutrients and their respective combination, water temperature, sunlight, and rainfall. These are consequently difficult to predict with any degree of accuracy. Storm run-off from the areas traversed by the canal can also contribute to waters with increased nutrients and therefore the potential for algae proliferation. These run-offs may also add to the nematode population in the canal water.

Both Giardia Lamblia and Cryptosporidium Pathogenic Protozoan organisms are possible contaminants in the Zai WTP surface water source. There are no water quality standards for these organisms in Jordan. Despite this, both of these organisms can be fatal to immune deficient people such as infants, the elderly, and those on kidney dialysis machines. However, these organisms can be inactivated and removed to acceptable levels through disinfections and good plant operation.

Analyses and Conclusions

1. There has been no history of catastrophic equipment failures, operating problems, or unsafe working conditions previously.

2. The incident had a large impact on Jordanian citizens living in the western Amman region, and had no international or regional relevance.
3. Plant operation was carried out within the standard operating procedures, and has been operating in the same manner for the last twelve years, with an accident free record.
4. There were no safety or maintenance violations that could have led to such an incident.
5. ZAI WTP is managed by the Jordan Water Authority (JWA), and had a clean, safe operational record. Despite this the then Minister of Water & Irrigation, Dr. Monther Hadadeen, made two conflicting press remarks. These indicated that the ZAI WTP staff had failed to react to the problem faced and were late to shut down the water supply, claiming that the plant had failed to cope with the problem sufficiently.
6. MWI and WAJ took a chain of actions. These included:
   a. Stopping the water supply to the Amman region.
   b. Providing citizens with clean drinking water from other supplies.
   c. Forming an investigation committee to pin point the causes of incident.
   d. Calling on the WHO and other specialized teams from Germany, Norway and the USA for analysis and recommendations.
   e. Maintaining a very close watch on all possible causes of the incident through monitoring raw water sources leading to the ZAI WTP.
7. Citizens of Amman were supplied with unpleasant water that had a bad smell and was contaminated with algae for few days
8. According to the Ministry of Health's official spokesman, there were no medical reports indicating any health problem suffered by citizens of the affected region.
9. The incident had no local environmental consequences and was limited to a specific region.
10. The incident did not have any economic affect on the community, apart from local citizens having to buy bottled drinking water for some time. In addition the government provided citizens with drinking water from other sources by tankers, and excused citizens in the affected region from paying their water bills for three months.
11. A more stringent monitoring system was enforced by JWA, to make sure that all drinking water supplied by its distribution system followed the Jordan Drinking Water Specification #286-2001.
12. WAJ has now contracted the Royal Scientific Society (RSS) Laboratory to monitor the water sources in Jordan. The contract covers the Zai WTP and its conveyance system.

Recommendations

1. Relocate PAC application points to the vault on the raw water line upstream with the regulating reservoir.
2. Use ferric sulfate for coagulation instead of the alum used in the plant.
3. Increase the capacity of powdered activated carbon feeders and slurry pumps to 35 mg/L each at full plant capacity.
4. Relocate the application of potassium permanganate to the raw water from the present location.
5. Add chlorine dioxide to the raw water at the intake pumping station as primary disinfectant and to aid in taste, odor and nematode control.
6. Add a perforated inlet wall to the fluctuation basin to reduce short-circuiting in the first stage, to improve fluctuation, and to make permanent the application points for flocculant polymer aid at the second and third stage flocculators.
7. Convert the existing mechanical electrical motor driven rapid mixer for the coagulant chemical and coagulant aid to hydraulic flash mixing. This would utilize the available head at the plant and creating savings in electrical and chemical costs.
8. Add perforated outlet walls in the sedimentation basin and abandon the finger weirs and troughs, to improve the basins effectiveness in removing fine floc and minimize carryover on to the filters.
9. Modify the filter operations and controls to allow for the elimination of the initial turbidity spikes immediately following the startup after the back-wash.
10. Use a filter aid polymer to help in the performance of the filters and in the removal of dead nematodes.
11. Replace the existing filter surface wash water system with an air scour method for full-depth filter media cleaning.
12. Convert the constant speed water recovery pumps to variable speed pumps.
13. Modify the piping for the storage tanks at four of the raw water pump stations, and add new piping to avoid stagnation and algae growth.
14. Add ferric chloride to the raw water at the head of the KAC to precipitate out phosphorous, one of the nutrients that algae depends upon.

References

i A comprehensive National Water Data Bank (NWDB) has been established and kept at the MWI, and will be aided by a Decision Support Unit. Additionally, this NWDB will be supported by a monitoring program, data collection system unit, data entry, update, data processing & dissemination, and will become a terminal regional data bank set up. (http:llwww.mwi.gov.jo/watersituationl.htm).

ii JWS has been issued since, and reviewed annually. For more see JWS/2000, or any newer edition.

iii Wadi is the Arabic name for valley.

iv JWS & P, pp18-19.

v Salt is 10 miles west of Amman.

vi Annex -2.

vii The KAC is an open concrete canal used primarily for irrigation, with a design capacity of (20) m3/sec at the initial entrance, reducing to (2,3)m3/sec. At the end of the canal, and is 100 km long, approximately 65 kilometers to the point of the Deir Alla intake. Conveys water from the different sources for agriculture purposes.

viii Yarmouk River. One of Jordan River sources, Yarmouk river flows through Syrian lands, and forms the Natural international boundaries between Jordan and Syria, meets with Jordan River about (5) km south of Lake Tiberius. Yarmouk River water is diverted to KAC through a receiving canal.

ix Wadi El-Arab Dam, is (82.5) meters high located 3 Km east of KAC. The Dam total capacity is (20) m m3 mainly used for irrigation of (12500) donums, providing population in the area with their need of drinking & house use water, Produce electrical power and supply KAC with raw water.

x AL-Mukhaibeh Wells. Wells are located at (8) km east of Adasiah Tunnel, Water is transferred through a 10 km long cement open canal, at a flow rate of (1.5)M3/Sec, to a point 500 meters from the tunnel. Total water supplied is about (16) MM3/Yr.

xi Lake Tiberias. After the Jordanian – Israeli Treaty was signed in 1994, Jordan started to about (50) MM3/Yr, from Lake Tiberias through a 32" pipe line from the lake to KAC entrance point.

xii The Japanese government has submitted a grant for the improvement of water supply system to the Greater Amman area, which included the improvement of Zai WTP to a capacity of (90)MCM/Yr.

xiii American Expert Michael Ring from Stanley Company has given an expert opinion on water incident in Jordan to press and said Zai WTP has been designed to treat running surface water only, and not stagnant water, of that kind that comes from lake Tiberias, this meant that the Zai WTP is not qualified to treat water with organs, materials, algae, or any other unidentified materials. Source: www.jordanembassyus.org.+zai+water+treatment.

Annex - 1

Algal Types Found in Clean Water and Polluted Fresh Water

Algal Group	Clean Water	Polluted Fresh Water	Wastewater Stabilization Ponds
Blue-Green	Aphanotheca Microcoleus	Phormidium Merismopedia Anabaena Oscillatoria Gloeocapsa Lyngbya Arthrospira	Spirulina Schizothrix
Green	Ankistrodesmus Ulothrix Staurastrum Lemanea Rhizoclonium Chladophora Micrasterias Hildenbrandia	Tetraedron Chlorococcum Spirogyra Chlorella Actinastrum Stigeoclonium Closterium	Closteridium Closterium Cosmarium Scenedesmus Golenkinia Polyedriopsis Planktospaeria Diacanthox Dictyosphaerium Chodatella Closteriopsis Schroederia
Flagellates	Rhodomonas Chrysococcus Phacotus Chromulina	Euglena Chlamydomonas Carteria Lepocinclis Pyrobotrys Phacus Chlorogonium	Chlamydomonas Massartia Pteromonas Cryptomonas Chroomonas Vacuolaria
Diatom	Surirella Cyclotella Navicula Meridion Pinnularia Cocconeis	Gomphonema Nitzschia	-------

Table 1-1

Algal Group	Algal Species	Odor when algae are		Taste
		Moderate	Abundant	
Blue-Green	Anabaena	Grassy, Musty	Septic	----
	Anacystis	Grassy	Septic	Sweet
	Gomphosphaeria	Grassy	Grassy	Sweet
	Oscillatoria	Grassy	Musty	----
	Rivularia	Grassy	Musty	----
	Aphsnizomenon	Grassy, Musty	Septic	Sweet
Green	Actinastrum	----	Grassy, Musty	----
	Chlorella	----	Musty	----
	Closterium	----	Grassy	----
	Cosmarium	----	Grassy	----
	Gloeocystic	----	Septic	----
	Pediastrum	----	Grassy	----
	Scenedesmus	----	Grassy	----
	Spirogyra	----	Grassy	----
	Staurastrum	----	Grassy	----
	Ulothrix	----	Grassy	----
Flagellates	Ceratium	Fishy	Septic	Bitter
	Chlamydomonas	Musty, Grassy	Fishy, Septic	Sweet
	Euglena	----	Fishy	Sweet
	Glenodinium	----	Fishy	----
	Peridinium	Cucumber	Fishy	----
	Synura	Cucumber, Muskmelon	Fishy	Bitter
	Volvox	Fishy	Fishy	----
			Fishy	
Diatom	Cyclotella	Geranium	Fishy	----
	Diatoma	----	Aromatic	----
	Fragilaria	Geranium	Musty	----
	Synedra	Grassy	Musty	----
	Tabellaria	Geranium	Fishy	----
	Melosira	Geranium	Musty	----
	Asterionella	Geranium	Fishy	----

Table 1-2

Algal Group	Filter-Clogging Algae	Algae Interfering With Coagulation	Algae Causing Coloration of Finished Water (Color)
Blue-Green	Anabaena Anacystis Oscillatoria Rivularia	Anabaena Gomphosphaeria	Anacystis (Blue – Green) Oscillatoria (Purple-Red)
Green	Chlorella Closterium Palmella Spirogyra Tribonema Ulothrix	-----	Cholrella (Green) Cosmarium (Green)
Flagellates	Ceratium Peridinium Dinobryon Trachelomonas	Euglena	Ceratium (Rusty Brown) Chlamydomonas (Green) Euglena (Red)
Diatom	Cyclotella Tabellaria Cymbella Diatoma Fragilaria Navicula Nitzchia Asterionella Synedra Melosira	Synedra Asterionella	-----

Table 1-3

Annex - 2

Drinking Water Test Parameters & Limits

Unit	Parameter	#	unit	Parameter	#
SU	PH	2	°C	Water Temp	1
µs/cm	EC	4	Mg/L	DO	3
Mg/L	T – P	6	Mg/L	NO3	5
Mg/L	Br	8	Mg/L	PO4	7
Mg/L	Na	10	Mg/L	T.Kj - N	9
Mg/L	Mg	12	Mg/L	Ca	11
Mg/L	Cl	14	-	SAR	13
Mg/L	HCO3	16	Mg/L	B	15
Mg/L	TSS	18	Mg/L	TDS	17
MPN/100mL	TTCC	20	MPN/1oomL	TCC	19
Count/mL	Total Algae Count	22	Egg/L	Intestinal Nematodes	21
Mg/L	As	24	Mg/L	Al	23
Mg/L	Cd	26	Mg/L	Ba	25
Mg/L	Cr	28	Mg/L	Co	27
Mg/L	Fe	30	Mg/L	Cu	29
Mg/L	Li	32	Mg/L	Hg	31
Mg/L	Ni	34	Mg/L	Mn	33
Mg/L	Se	36	Mg/L	Pb	35
Mg/L	Mo	38	Mg/L	Zn	37

Test	Unit	Limit	Absolute Maximum Limit
Cd	mg/ L	0.003	--
Cr	mg/ L	0.05	--
CN	mg/ L	0.07	--
Hg	mg/ L	0.002	--
Ag	mg/ L	0.1	--
Ni	mg/ L	0.07	--
Sb	mg/ L	0.005	--
TCC	MPN/100 ml	< 1.1	--
TTCC	MPN/100 ml	< 1.1	--
Free Living Nematodes (Larvae)	Count / 5L	1 alive / L	--

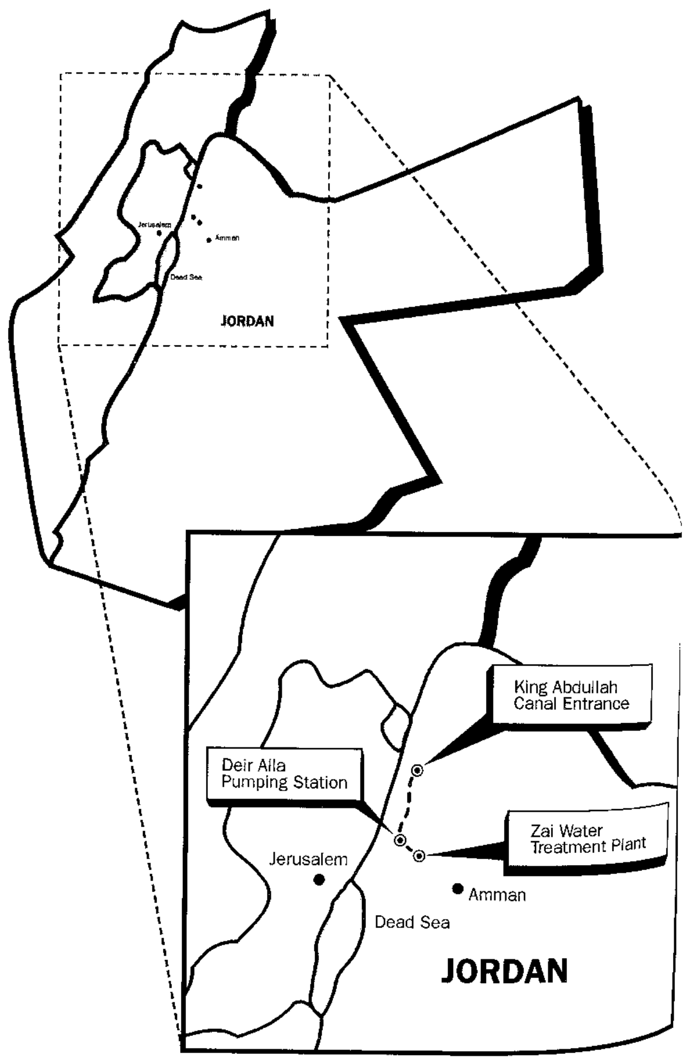
Table – 2

Jordan Specification # 286 – 2001

SO4	mg/ L	200	500
F	mg/ L	2.0	--
NO2	mg/ L	2.0	--
Al	mg/ L	0.1	0.2
Fe	mg/ L	0.3	1.0
Mn	mg/ L	0.1	0.2
Cu	mg/ L	1.0	1.5
Zn	mg/ L	3.0	5.0
As	mg/ L	0.01	--
Ba	mg/ L	1.5	--
Pb	mg/ L	0.01	--
Se	mg/ L	0.05	--
B	mg/ L	2.0	--

Test	Unit	Limit	Absolute Maximum Limit
pH	SU	6.5 – 8.5	--
Color	PCU	10	15
Turbidity	NTU	1.0	5.0
Cl2	mg/ L	0.2 – 1.0	--
TTHM's	mg/ L	150	--
ClO2	mg/ L	800	--
ClO3	mg/ L	--	--
NH4	mg/ L	0.5	0.5
NO3	mg/ L	50	70
TDS	mg/ L	500	1500
TH (as CaCO3)	mg/ L	300	500
MBAS	mg/ L	0.2	0.5
Na	mg/ L	200	400
Cl	mg/ L	200	500

King Abdullah Canal



Case Study Two

Palestinian Case Study: Gas Lighter Factory, October 1999

Dr. Hasan Dweik

Summary of Incident

October 21, 1999 is a landmark in the history of the Palestinian labor movement, women's movement and Palestinian life in general. At around 8.00 a.m., a fire broke out in a gas lighter factory, in the city of Hebron in the southern West Bank. Fourteen young women were killed, and the corpses were so badly burned that identification of the women was difficult. It was not possible to separate four of them as the fire had glued their corpses together. Twenty other people were injured as a result of inhaling toxic gases. The fourteen dead bodies were all buried in one collective grave in the vicinity of Dora Village as requested by their families.

The mother of two workers at the factory (one of whom was injured and the other of whom died) described the event, saying:

"At about 8:15 in the morning, I was drinking a cup of milk, and my son came in shouting that the factory where my two daughters work was on fire. I could not think. I left the house running, unaware of what I was going to see. The fire was fierce.... All I remember, from the whole catastrophe was the small pieces of my daughter's dress left stuck to a small piece of her body. She had a difficult life. She was forced to leave school and work to help our family and to provide some financial support to our poor family that was having a hard time to survive on a very low income and under a critical economic situation. My other sons completed high school, and the family could not afford to support their university education."

Dr. Dweik is Dean of the Faculty of Science and Technology and Associate Professor of Chemistry at Al Quds University. He holds a Ph.D. from The University of Aston in Birmingham, England. Dr. Dweik has also studied at The University of Jordan College of Science, and has served as a Fulbright Research Fellow at The University of Akron. He is the author or co-author of numerous articles and publications, most recently, Levels of Dioxins and Dibenzofurans Found in Various Environmental Sources of Contamination in Palestinian West Bank Territory. Dr. Dweik has participated in numerous international workshop seminars and conferences.

Her other daughter, Naela, who was working at the same factory and escaped the fire, described the tragedy, saying:

"When the supervisor was telling us about our duties for that day, we heard a strange noise downstairs. We all ran down. To our shock, the factory was on fire. Our spontaneous reaction, three of us, was to run out to the street and start screaming and shouting. The people gathered outside the building where the fire was already taking hold."

At 9:30 a.m., an hour and a half later, the only fire truck available arrived, but it was not in working order due to its age. The fire was getting closer to an electricity power converter. There was no exit out of the factory, and the owner of a local bulldozer passing offered to demolish the front wall of the factory to create an exit. The owner of the building refused. Later the Israeli fire brigade suggested the same action. The owner of the building refused again, and it was only after four hours of hard work by both the Israeli and Palestinian fire brigades and the Palestinian civil defense that they finally managed to put out the fire.

Social and Political Context

On top of the difficulties and disadvantaged position of the Palestinian people, they are also subjected to long-term organized violence. The incremental effect of this is increased vulnerability amongst various population segments, especially women, children and the poor.

What is worse is that the post-Oslo era did not improve the quality of life for most Palestinians. On the contrary, in the absence of coherent laws and measures of law enforcement, the evolving system perpetuated pre-existing improper terms of reference largely based on the tribal/caste system. Political affiliations of individuals and groups have also led to unequal resource distribution and opportunities for the people.

Table 1 below provides a summary of the total number of work injuries for the year 1999 by cause and severity of the injury.

Number of Injuries		Causes of Injuries							Severity of Injury			
District	Number	Physical	Chemical	Biological	Mechanical	Electrical	Falling	Burn	Mild	Moderate	Severe	Death
Jericho	84	26	2	-	23	2	29	2	42	34	8	-
Hebron	146	42	-	-	39	5	42	18	46	79	7	14
Bethlehem	97	23	7	-	28	3	35	1	58	-	36	3
Nablus	123	35	2	-	45	5	32	5	25	23	84	1
Jenin	34	12	-	-	15	-	4	3	10	16	8	-
Tulkarem	58	15	-	-	14	4	25	-	20	16	22	-
Salfeet	19	5	-	-	8	-	4	1	6	11	2	-
Qalqilya	25	12	-	-	10	1	2	-	15	7	3	-
Ramallah * Al-Beireh	9	-	-	-	-	-	9	-	-	4	3	2
Jerusalem	5	1	-	-	3	-	1	-	3	2	-	-
Gaza Strip	228	124	6	-	73	-	10	15	50	93	74	11
Total	828	295	17	-	258	20	193	45	275	275	247	31

Source: Ministry of Labor & Palestinian Trade Union, 2000

Palestinians are governed by at least five types of law: Ottoman-Turkish law, pre-World War I colonial regulations, Jordanian law, Egyptian law, and Israeli military orders.

Collectively and individually, these resulted in the cultivation of a culture where human rights are easily violated at all levels, including the Palestinian institutions and businesses. Consequently there is little incentive to minimize environmental and human risks in the work place.

The case of the Hebron lighter factory accident presents one evident example of this. Fundamental principles of occupational health and safety were overlooked. The workers' human and labor rights were completely violated, taking away the lives of 14 young, lower-class women and injuring tens of others, some of whom were children.

The Factory

The factory was on the ground floor of a four-story building in a densely populated area in the northern part of the city of Hebron. Its owner, Mohammad Walid Abedalrahman Asali, had no legal permit to operate his factory and did not follow any fire regulations. The factory had no fire exit and only one front door, which was usually closed after the arrival of the workers.

The factory was not properly ventilated. It had an internal floor, which was only 1.5 meters high, with men working downstairs and women upstairs in order to ensure that they were kept separate. The factory also employed twenty school boys aged 6-13 years, who would work after school for 50 cents per hour.

The factory had not followed the minimum requirements for occupational health and safety measures and had ignored the safety of its workers.

Direct Cause of the Accident

One of the workers described the accident as follows:

"A box filled with ready manufactured gas lighters fell down from the 12 year old boy who was working in the factory. It caused an explosion in a number of gas lighters and fire broke out fiercely. It started spreading all over the factory, which had closed windows and steel partitions that obstructed and prevented the girls working in the upper floor from running out. What made matters worse was the presence of a large amount of boxes filled with industrial candles used for lighting, large amounts of wool, and huge amounts of inflammable solvents used in the production of cleaning products."

Legal Status of the Factory

The only permit that the owner had was issued in 1997 enabling him to use the building as storage for refrigerated fruits and vegetables.

It was converted to a factory for the manufacture of cleaning products, without informing the relevant authorities, then again converted to a gas lighter factory that operated without a license. The factory had no records with the ministry of industry or the municipality of Hebron.

The community thought it was a sewing factory, but when workers started work there they reported that it was a multipurpose factory: cleaning products, clay products, mirror manufacturing, shaving raisers and gas lighters.

Response of the Local Community

At the time of the incident there was no legislation fully addressing the health and safety of workers at the workplace. Labor and environment laws were not yet passed by the Palestinian Legislative Council, despite the fact that many governmental and non-governmental organizations were heavily involved in the preparation of draft laws, driven by and concerned about many issues surrounding the workplace. Included were the following:

- Absence of contingency plans to cope with emergencies.
- Poor coordination and cooperation between and within NGOs and PA bodies in the fields of health, environment, legislation, civil service, and public affairs.
- Poor public health infrastructure and awareness.
- Absence of hazardous chemical response units.

Because of the multidimensional nature of these problems and multiplicity of key actors, it was very difficult to mobilize all those who could help with and reduce the risks of such an accident occurring. The public was aware of these weaknesses and as a result, huge demonstrations broke out in the city of Hebron for a few days after the incident. Demonstrators were holding black flags and banners demanding:

- The implementation of the law. Demonstrators wanted those responsible to be tried in court and sentenced.
- The resignation of members of the Municipality Council in the city of Hebron.
- More effective enforcement of legislation. This campaign was launched under the banner, the "Battle for Law."

A commercial strike took place in the city of Hebron and the neighboring villages. The Dora municipality consequently organized an emergency meeting for the 36 municipalities in the West Bank and Gaza. They met to discuss what measures should be taken to prevent such accidents from occurring again.

There was huge debate among the Palestinian society at large, including municipalities, ministries, women's movements and human rights movements. They put forward many recommendations and demands:

- The Palestinian Legislative Council propose the draft for the Palestinian Labor Law, which was not yet endorsed at the time. The council must take strong measures to enforce the law, in particular laws that deal with occupational hazards, health and safety.
- The Legislative Council must follow up on the findings of the investigatory committee that was established by President Arafat for this accident and try in court all those responsible.
- The owners of factories must provide adequate and proper places for workers to work in a safe and comfortable atmosphere, and take all measures necessary to provide the workers with protective clothing and tools.
- All industrial activities should be moved away from highly populated areas to industrial zones.
- Factories should be prevented from employing children under the age of 16 years.
- The concerned legal authorities (ministries and municipalities) must increase the process of monitoring and adequately implement and enforce legislations related to safety at work.

Response of the Palestinian Authority

The day after the accident, the Palestinian cabinet in its weekly meeting studied the accident in Hebron, and Chairman Arafat decided to establish a ministerial committee to investigate it further. The following were members of the committee in 2000:

1-Minister of Industry, Dr. Sadi El-Krunz
2-Minister of Local Government, Dr. Saeb Erekat
3-Minister of Labor, Mr. Rafiq Natsheh
4-Minister of Parliamentary Affairs, Mr. Nabil Amr
5-Member representing the police force
6-Member representing the Civil Defense

The committee, after a full investigation, expressed its concern on two tracks:

- Ensure that the proper legal actions and procedures are followed in dealing with this tragedy.
- Study in depth and evaluate the status of industry in the city of Hebron, to ensure that proper safety regulations were met and to ensure compliance with these regulations. The committee noted that most industrial activities were at present in highly populated areas or inside houses. It was recommended that this trend be changed.

On track one it was decided that the case will be followed legally in the courts and those responsible will be prosecuted. Secondly, the president on considering the ministerial committee recommendations decided to:

- Ask the Minister of Local Governorate to re-establish the municipality council of Hebron city.
- Create a new post for a judge in the municipality court in Hebron.
- Construct immediately a civil defense building and provide all the equipment necessary for a rapid response to accidents.
- Ask the general safety committee to proceed with their responsibilities.
- Ask the minister of industry to establish the industrial zones away from highly populated areas.
- All factories must re-establish their legal status within three months.
- Accelerate the process of drafting the following laws:
  - Rules and regulations of licensing
  - Law of companies
  - Law of industry
  - Law of environment
  - Law of standards and quality control
  - Law of labor.
- The ministerial committee must verify that the families of the lost women receive proper compensation according to the court rulings.

Lessons Learned

The Ministry of Labor has requested that the Ministry of Industry provide a list of all the industrial activities that operate in Palestine, indicating those that operate with licenses authorized since the establishment of the Palestinian Authority. This list is designed to help inspectors identify these factories and begin the monitoring and verification process. This will ensure that the relevant safety and occupational health measures needed for the different industries are enforced.

Ministers concerned must coordinate a multi-sectarian approach regarding the issues of licensing and permits for industrial activities. They should also be able to monitor and inspect these factories to ensure the enforcement of safety and occupational health regulations.

Studies have shown that more than 70 % of the Palestinian labor force is not insured against various occupational accidents. Recent studies have also shown that if a worker has an accident resulting in death, then by law their family is only entitled to the sum of their salary for 250 working days. Seeing as the average monthly salary is $100, the compensation for the loss of life is very low. It is therefore vital that factories provide adequate insurance for their workers. Other recommendations include:

- The establishment of the National Council for Safety, Occupational and Environmental Health.
- The establishment of a committee for occupational safety, health and environment in the working place.
- The development of a national policy and plan for the protection of workers from hazards in the workplace.
- The enforcement of appropriate inspection procedures within the Ministry of Labor.

Who is Responsible?

This was the biggest question that arose after the incident.

Was it the owner of the factory who was responsible for the accident as a result of his desire to increase profits in a short period of time without spending money on an adequate safety in the workplace?

Was it the Ministry of Local Governorate that was responsible due to its authority over the municipalities?

Was it the Ministry of Planning that was responsible for the accident due to its inability to prevent the factory from operating in a highly populated area?

The public expressed its anger against the municipality, as the body responsible for monitoring and verification. The municipality was the city's institution that received the public complaints, and investigated them.

The Government Officials' Perception of Responsibility

The chairman of civil defense in the West Bank stated that it was the owner of the factory who failed to take the appropriate action to ensure the safety of its workers. He had failed to install fire extinguishers and did not ensure that he had the proper license for the factory.

Accusations have also been made against the Minister of Industry and the chairman of the municipality. The chairman of the municipality refused to accept responsibility for the accident. He said that the municipality issued a license for a frozen fruits and vegetables factory, and it was the responsibility of the Ministry of Industry to inspect that factory.

The Minister of Industry said that the responsibility was shared. They claimed that this was not the only incident of its kind in the West Bank and stated that it was the responsibility of the municipalities to coordinate with the Ministry of Industry. They also restated that the gas lighter factory in Hebron had not been licensed by the Ministry of Industry.

The Ministry of Industry admitted that in order to avoid such disasters it was necessary for coordination between the Ministry of Industry, Labor, Health, Agriculture, Governorates, and Municipalities.

The Owner's Responsibilities

- The factory was operating without the proper license.
- There were no guidelines or regulations provided by the owner for the workers on the proper response in an emergency.
- The owner did not install proper ventilation.
- The doors of the factory were locked immediately after the arrival of all the workers, to hide what was going on inside the factory.
- All inflammable materials were stored inside the factory and close to the workers
- Boys were employed and exploited in the factory.
- The owner had positioned the factory in a highly populated area.
- The owner of the factory had failed to notify the relevant governmental bodies when he converted the building from a frozen fruit and vegetable store to a gas lighter company.
- The owner of the factory failed to adopt the basic health and safety procedures which relate to the following: environment, building, containers, electrical systems, fire protection equipment and tools, hazardous materials, handling material, personal protective equipment, pressurized equipment, production equipment, personnel support equipment, powered equipment storage facilities, walkway protective guards, safety devices, controls, lifting components, hygiene and first aid facilities.

Responsibilities of the Government Authorities

- To ensure that laws are passed regulating labor practices in the workplace
- To share and coordinate the responsibilities between the ministries, especially in the areas of labor, health, industry and the environment.
- To install an effective system of industrial monitoring and inspection of all industrial activities.
- To ensure the existence of occupational safety and health laws and regulations, as well as their enforcement.
- To provide industrial sites away from densely populated regions.
- To better equip the Palestinian fire brigade with the adequate equipment and tools needed to fight fires in the future.
- To ensure a greater human resource capability, especially when dealing with chemical incidents.
- To strengthen the public health infrastructure through the provision of:

a. hazardous chemical response units.
b. specialist laboratories.
c. contingency plans to cope with various industrial hazards.
d. advanced coordination and the provision of assessment teams.

Where Do We Stand Today?

In the aftermath of the accident, the families of those involved have been compensated by the Palestinian Authority. A sum of $1000 per person that perished in the fire was distributed to each family. Of note, the owner of the factory has been taken to court. However the case is presently unresolved due to the lawyers' continuous delays. Not only does the factory now cease to exist, but there has also been a move to process and endorse relevant laws that prevent such an accident from occurring in the future (see appendix for information on these laws).

11.6.03, 19:00 p.m.:

- The reaction solution began to leak from the reactor. Following strong smells, the production manager present immediately shut off all steam systems in the factory.
- The production manager dealt with the incident by shutting down all the steam systems, calling in the factory chemical engineer who was in charge of safety, and by pouring water around the installation. He did not contact the police or any other authorities.
- The police received calls from citizens complaining of strong smells in the area, which were causing sickness.
- A message was sent by the police to the fire brigade informing them of the incident.
- The event was then dealt with by the Ashkelon fire brigade, with professional assistance from the chemical engineer from the factory and a representative from the Local Environment Authority.
- During the event, the Ministry of Environment's mobile monitoring laboratory sampled the atmosphere. They did not manage to detect a specific component in the surrounding area due to a lack of information on potential hazardous compounds. As a result, no immediate estimates on the dangers caused by the hazard could be achieved. Consequently improvisation was used instead of professional reactions to deal with the incident, such as cooling the reactor down by pumping water through the heating system.

Results:

- Six people outside of the factory were affected by the discharge, reporting symptoms of general malaise, dizziness and nausea.
- Chemical analysis of the samples taken from the reactor after the event did not detect traces of di-methoate.
- The Ministry of Environment appointed an Inquiry Committee.

Main Findings of the Committee

- The steam valve of the reactor, which was shut off at 14:00 p.m., was probably the correct action.
- Shutting down the steam valves at 15:30 p.m. definitely stopped the flow of steam to the reactor.
- The overheating of the reactor caused the exhaust of noxious compounds to be emitted.
- Decomposition compounds at a temperature higher than 120°C were dispersed after a PVC tube that connected the reactor and the scrubber melted, disconnecting the system.
- The temperature gauge of the reactor was known to be out of action, but was overlooked.

Committee Conclusions

The lack of documentation on each activity carried out during the process, made it impossible to deny the occurrence of human error regarding the quantities and materials that were added to the reactor.

The production manager did not have any written guidelines explaining what to do when a fault in the process occurred. There were no written guidelines outlining the potential hazards of the production process, or guidelines on the action needed to be carried out in the case of an emergency.

- The only data available in the plant concerning potential hazards was information leaflets issued by the Center of Industrial Hazardous Materials of the Home Front Command.
- Due to lack of control over the heating stages of the reaction, due to the dysfunctional temperature gauge on the reactor, the temperature reached levels of more than 70°C in the primary stages of the process. At this temperature the di-methoate product was destroyed.
- The exothermic reaction occurred about 6 hours after the start of production and therefore indicates that an autocatalytic chain reaction occurred inside the reactor.
- The chemical analysis of the reactor's contents after the event showed the presence of destructive products.
- The melting of the PVC pipe indicated that high temperatures of 120-130°C were reached.
- The main cause of the incident was the uncontrolled heating of the reaction, caused by changes in the structure of the reactor and the addition of the scrubber. These parameters changed the characteristics of the heat transfer and consequently resulted in severe overheating.
- The structural changes in the reactor required a gradual approach to the renewal of the production process, using conservative scale pilot experiments, before starting full-scale production.
- The operation of the pilot with a functioning temperature gauge could have detected the overheating process and would have avoided the incident.

External Actors' Reactions

Regional Environmental Authority (R.E.A.)

The Regional Environmental Authority's responsibility during the event includes:

- A hazard assessment of risks to the population outside of the plant.
- Possession of data and knowledge of the possible hazards the plant could cause.
- Providing professional safety guidelines to those first at the incident, such as the Police and firefighters.
- Cooperation with other professional actors, such as the M.O.E. Mobile Environmental Monitoring Units, factory safety and plant engineering personnel.

Actual response during the incident (as concluded by the inquiry committee):

- The R.E.A representative showed great personal devotion and active involvement in controlling the incident inside the plant.
- The R.E.A. representative did not have any data (plant safety files) or information on expected exhaust pollutants.
- Estimates on the time-scale of the hazard were not carried out during the incident.
- No orderly sequence of reports, or timings during the incident were distributed to the relevant actors in the district, or to the M.O.E.

M.O.E. Mobile Monitoring Units (M.M.U.)

The M.M.U.'s main tasks are:

- Detection and Identification (D&I) of noxious exhaust pollutants.
- Quantification of the pollutants present in the area.
- Hazard estimates.

Actual response (as concluded by the inquiry committee):

- The O.P. detector was out of action (indispensable monitoring tool).
- The M.M.U. crew was not familiar with the expected pollutants in cases of dimethoate formulation. Furthermore, this information was not available from the plant or the M.O.E. professionals.
- The mobile laboratory did not use its drager kits, despite their suitability, due to a lack of knowledge on the nature of the pollutant.
- As a result of the above, the M.M.U. did not perform its main task of environmental hazard estimation.

The police force

The main responsibilities of the police are:

- Area control, according to the specific incident. This includes the establishment of a forward command post near the site, closure of intersections, evacuation of population, etc.

Actual response as concluded by the inquiry committee:

- The police patrol teams had suitable standing orders regarding intersection closures to be activated in such an event.
- The police were the first to arrive at the site and called for the firefighting units.
- The police left the site before the end of the event, but kept radio communications on.
- They did not establish a forward command post at the site.
- The committee reported that all police actions were well coordinated with the relevant actors, and that radio contact was well used.

Fire brigade

Actual response as concluded by the inquiry committee:

- The firefighting units acted positively and in a way to be praised, despite the conditions that developed. The cooling of the reactor by first pouring water externally, and later pumping it through the reactors heating system was the correct way to neutralize the incident.
- There was good cooperation with all relevant actors.

Incident Consequences

Human consequences

- Foul odors were discharged from the factory, which affected people locally.
- Six people received medical assistance at the local hospital as a result of the incident.

Evaluation and Suggestions

Evaluation of pre-incident preventive measures

Preparedness of relevant external forces:

- **Firefighting units:** Were well prepared (equipment and doctrine)
- **Police units:** Were well prepared (standing orders, equipment and doctrine).
- **Regional Environmental Authorities:** Did not have pre-prepared data on issues concerning safety, and did not have an adequate routine or standing orders procedure for the event.
- **M.O.E - Mobile Monitoring Units (MMU):** Did not have relevant safety data at hand and were not in a state of operational readiness when the incident occurred. Important equipment was not in good working condition and they were not professional enough to deal with the task.

Preparedness of relevant internal forces:

- **Management:** Did not apply the basic rules of industrial safety and did not take responsibility for the incident.
- **Safety and Chemical Engineering:** No safety or hazard files were prepared or available at the plant. The Standard Operational Procedures were not applied for the initial running of the new production unit (Pilot).
- **Maintenance:** Did not keep the temperature gauge on the reactor in full working order.

Missed opportunities and social and political limitations

The laboratory findings with unusual results were reported to the production manager, who considered them insignificant and therefore did not stop production. However these results did not inform him of the faulty temperature gauge. Another factor that impeded the effective preventive measures from being carried out was the weak relationship between relevant managerial actors.

Suggestions for pre-incident preventive measures

In order to minimize the probability of future incidents, implementation of the following suggestions should be helpful:

Safety Standards:

There should be a Safety Approval Procedure (S.A.P.). This approval procedure should be carried out periodically, at least once a year and in the case of:

- A new or renewed production line.
- Changes in the production line and its systems (heating, controlling, mixing etc).
- New products or processes.
- Changes in, or the replacement of raw materials (including suppliers).
- Any other essential changes in a production procedure.

This S.A.P should verify the existence of all safety procedures regarding each product and each production line, and should take care to update them when necessary.

All production procedures should include an Operators Checklist (O.C.) prepared by the engineering unit. This should include:

- The provision that all controlling meters and gauges are in working order.
- The existence of an updated and valid S.A.P.
- All productions should also receive prior approval from the safety engineer, after verifying the O.C. results.
- This list must be updated as part of the S.A.P.

Each production line should have a "Fault Handling - Step by Step Guide." This must be prepared prior to the approval of each line, and in the case of multi purpose lines, as well as for each product.

Each product produced should have a "Hazard Assessment Statement" that will be known to each safety engineer in charge, the production manager on duty, the line operators, maintenance and, the local Environmental Authorities.

Policies:

As described above, both the S.A.P. and the O.C. are the basic issues that need to be implemented to ensure a "Good Manufacturing Policy."

Operations:

- Should prepare the Fault Handling Guide and the Hazard Assessment Statement before the first production, and update them periodically and when necessary.
- Should prepare a communications list for emergency cases, which should also be included in the Fault Handling Guide.
- Should establish a command chain, including external and internal forces, known and understood by all involved in the production facility.

Training:

- All safety measures should be known by each worker, and especially by all managers (engineers, production managers etc.). In order to achieve this, periodic training should be implemented.
- Periodic exercises, with and without the external forces, should be done. These will improve environmental community awareness.

Plant modification:

This should be required as a result of the Hazard Assessment Statement and the Good Manufacturing Policy and should be followed up by the local Environmental Authorities instructions.

Evaluation of the Post-Incident Response:

- All relevant actors were on the site. Communications between the actors were good, except for the internal production manager, who did not decide to call for external assistance when necessary. The external actors involved were called in by the police force, following neighbors' complaints. The external professional forces suffered from a lack of information, knowledge and skills, as well as a low level of readiness. On the other hand, the police and firefighters were ready, and carried out their jobs as expected.
- Although the "environment professional" units were not able to do their job as expected, the internal forces, with assistance of the M.O.E. representative, together with the firefighters, took the right steps to deal successfully with the incident. Therefore, there was no missed opportunity.
- There were no irrelevant factors that limited or impeded the response of the relevant actors during the incident.

Post-Incident Response, Issues and Conclusions

The police and the firefighters responded exactly as expected. The M.O.E and the M.M.U. also responded on time, however technically they were unprepared and therefore unable to do their job efficiently.

- It was the people in charge internally, i.e. the production manager and the safety engineer who should have contacted the external forces, yet did not. Had the safety engineer been aware of the danger level outside of the plant, he could have warned the police force sooner.
- In order to make the response faster and more efficient, the internal forces in the plant must notify the police of any incident, even if they estimate that they can

deal with the incident alone. The police will then take command and coordinate the rest of the forces upon need. This will be done according to a contingency coordination plan, prepared beforehand.

- As long as there is sufficient information in the hands of the police officer controlling the incident, he can operate and direct each force as needed, and can disseminate information to the surrounding residents, media etc. Proper preparedness and information sharing with all actors including the industry, local authorities and regional external forces will in the long run benefit all involved.
- In addition, there should always be a post-incident report filed. This will ensure that lessons are extracted from the incident and not repeated again in the future. The report should be based on a standard scheme and include areas where action is needed for the future. The coordinator, i.e. the police officer in charge, should also be in charge of controlling those action items. In order to make this system work, the police should be able to legally charge anyone who dose not complete his action item.

Lessons Learned

Pre-incident preparedness and information sharing is essential. It includes:

- Assimilating suitable factory policy as described above and maintaining Good Manufacturing Policy, Safety Approval Procedure, Operator Checklist, Fault Handling Step-by-Step Guide and Hazard Assessment Statement.
- Understanding of control and coordination.
- Nominating a chief police officer to serve as a coordinator.
- Carrying out exercises on a regular basis as part of the safety training.
- Establishing an information center for hazardous materials.
- Implementing and verifying of "by the book" and "scale-up" procedures.

Case Study Four

Egyptian Case Study: Field Petroleum Company, May 1998

Major General (ret.) Salah Eldin Selim Mohamed

Abstract

This paper explains a fire accident that occurred in May 1998, at an Egyptian field petroleum company in the Egyptian eastern desert, on the shore of the Gulf of Suez. This fire was the result of a lightning strike on a crude oil processing plant. Other contributing factors to the fire included defects in the ability to detect a fire quickly, a delay in the alarm system, a failure within the firefighting network, and hesitation in calling the professional firefighting teams. As a consequence, five degassing, operational and storage tanks were burned and some firefighting personnel were injured, including two seriously. The consequences included the closure of the oil production plant due to the devastation caused by the fire, as well as the environmental damage that was sustained.

The Egyptian Ministry of Petroleum has generally used lightning protection as a means of diminishing the risk of fire and the explosion of petroleum tanks and equipment in its companies and refineries. Since the incident, an alternative, modern and more secure processing unit has been installed to replace the damaged plant. This has incorporated new technology, which enables the heater to increase the crude oil temperature. Investigation teams have also recommended updating meteorological maps, carrying out regular inspections of the processing plants and their steel structures, implementing fire prevention and lightning protection

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measures in the plants, and establishing a well-trained group for crisis managemen within these petroleum companies.

Introduction

Oil and gas are not usually salable as they come from the wellhead. Crude oil is often produced in conditions that make handling it difficult such as high velocity, high-pressure, turbulence, high viscosity, and the use of a variety of hydrocarbon liquids and gases mixed with water, and water vapor. Crude oil contaminants make oil and gas costly to process and transport. These include water, wax, solids (sand and shale sediments), and sour gases (carbon dioxide and hydrogen sulfide). This makes it vital to prepare the oil or gas for transportation from the production site to the refinery, or for sale. The main reasons for processing oil are:

- To remove and/or dissolve gases through depressurization and by increasing the temperature of the rude oil to stabilize it. This then facilitates both the storage an the transportation process.
- To remove and/or emulsify water, which is often produced with crude oil. This wi then reduce the transportation costs of the pipelines and shipping.
- To decrease the salt content of crude oil to avoid corrosion and problems of scale deposition in the tankers and refineries.
- To carry out a de-oiling process on the removed (separated) water for economic and environmental reasons.

Description of the Plant

How the treatment plant operates

The well stream (about 30,000 bbl/d) was collected and transported from 6 different fields, located in nearby areas. It was first passed through a series of devices to separate the crude oil and water from the gases and to treat the emulsions for removing water, solids, and undesirable contaminants. The oil was then stabilized, stored and tested in the laboratory for purity. A portion of the produced gas was adjusted to feed a series of direct heater tubes used to raise the crude oil temperature. The remaining portion is then burned through the flare.

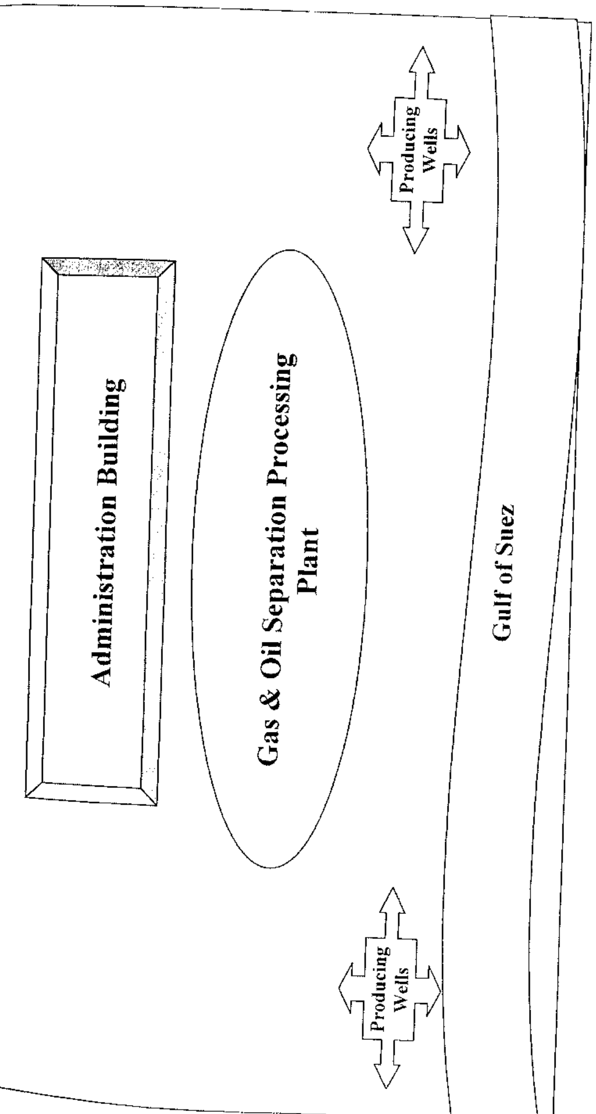
The region surrounding the gas and oil processing plant

The gas and oil processing plant was surrounded by artificially producing wells and an administration building. Here oil was produced with the help of the sucker rod pumps. Figure (1) shows the area surrounding the burned plant.

Process for the treatment of crude oil in the plant

The collected stream of untreated crude oil was chemically injected using de-emulsifiers through the injection line in the main header manifold. The liquid mixture (gas and oil) then entered the two interconnected degassing units (A & B) as

Fig. No. (1) The Area Surrounding the Burned Plant.



shown in figure (2). The degassing units were considered as vertical separator tank (6 meters high) and were mounted on a 6 meter high skid. The oil was then separa from gas the in the degassing unit by the force of gravity. Oil, which is heavier tha gas, fell to the bottom of the degassing tanks and was then removed and sent to the heater, which increased its temperature. The lighter element, the gas, was removed from the top of the degassing tanks and a portion of the separated gas was burned i the direct heater, with the remaining portion being burned through the plant flare.

The cold incoming oil emulsion was passed through a fire tube in the direct heat to heat the oil. The emulsion was then flown to the top of the two interconnected atmospheric degassing tanks (C & D). Here, the gas broke out of the emulsion as it splashed over the pan and was atmospherically vented into the air. The degassing units were also vertical separator tanks (6 meters high) and were mounted on a 6 meter high skid, with a one-meter high crude oil level.

The crude oil emulsion was then sent to two operational tanks (E & F), which were vertical tanks of 30,000-bbl capacity and 9 meters high. In the operational tanks free water and sediment fell out and the oil-water emulsion settled and was then separated. The water fell to the bottom of the operation tanks, while the crude oil rose upwards (due to the difference in specific gravity). It was then passed through an oil outlet located at a height of 7.8 meters, into two storage tanks of 15,000 bbls and 30,000 bbls capacity (G & H). The storage tanks were located at the shipping area, and one tank was filled, while oil was run from the other.

Fire protection equipment

The gas and oil processing plant was equipped with a firefighting system, which had access to the operational and storage tanks. A 6% fluoroprotein foam and water fire protection loop surrounded the process area. This meant that the operational tanks and storage tanks were equipped internally to inject foam above the level of the crude oil and externally, with the use of a cooling shower, to cool the unfired tanks. On top of this the plant was equipped with water monitors, safety hoses and dry powder extinguishers. Figure (3) shows the flow chart for the fire fighting system at the plant.

The processing plant's manpower

The permanent labor in the plant consisted of two operators per shift (day/night). The maintenance and other work was carried out during the day shifts as a safety measure, while the night shift concentrated solely on monitoring the operation process.

The Nature of the Fire and the Scenario of the Accident

How the fire began

At 5:40 a.m. on May 3, 1998 one of the two plant operators observed a sudden fire that began in the two degassing tanks (C & D). The operator called the company firefighting team. The operator then shut down the processing plant, changed the flow direction and sent the crude oil to another plant, exactly as he had been trained to do in the case of an emergency. Figure (4) shows the sequence of the fire in the processing plant.

The company firefighting team arrived at the plant at 6:00 a.m. and started to fight the fire using water and 6% fluoroprotein foam. At 7:12 a.m., degassing tank C exploded and the fire spread to the operational Tank F.

Firefighting teams at nearby petroleum companies along with the civil defense arrived at the scene to cooperate with the company firefighting team. They began to fight the fire in tank F by isolating oxygen above the crude oil. This was done by an injection of foam through a foam box and cooling the water in the undamaged tanks. Unfortunately, they failed to inject the foam as they failed to break the case on the box (the foam box materials are usually made from Fiberglas). Consequently they proceeded to use a firefighter in a basket, hung in a crane to ensure that the foam reached the surface of the crude oil inside the tank on fire. Bad weather conditions however restricted the efficiency of fighting the fire due to strong winds.

At 1:27 a.m. on the second day, the tank exploded, and the fire extended to the storage tanks (G & H). Consequently the fire moved closer to the administration building.

Steps followed to fight the fire

The fire teams worked in relays and concentrated their efforts on the storage tanks. This was achieved by:

a. The injection of foam above the crude oil through a foam box designed for this purpose.
b. Draining crude oil stored in the storage tanks to the Gulf of Suez.

At 1:41 p.m. the fire had been successfully put out in tank G, and at 8:24 p.m. this was repeated for storage tank H, while continuously cooling tank G.

At 9:50 a.m. on the third day, the fire in the operational and degassing tanks was under control.

By 11:45 the fire had been put out. The processing plant remained under observation for the next 24 hours. Many investigation teams visited the accident site to gather the required information to understand the causes of the accident. Company technical teams, safety and administration committees also arrived at the site to evaluate the total losses, safety precaution measures and the technical procedure required to rehabilitate the damaged plant. See appendix (1).

Losses, Casualties and Environmental Damage Caused

The losses can be summarized in the following:

Direct losses

- Two degassing tanks.

Fig. No. (2) Flow Diagram for the Burned Plant

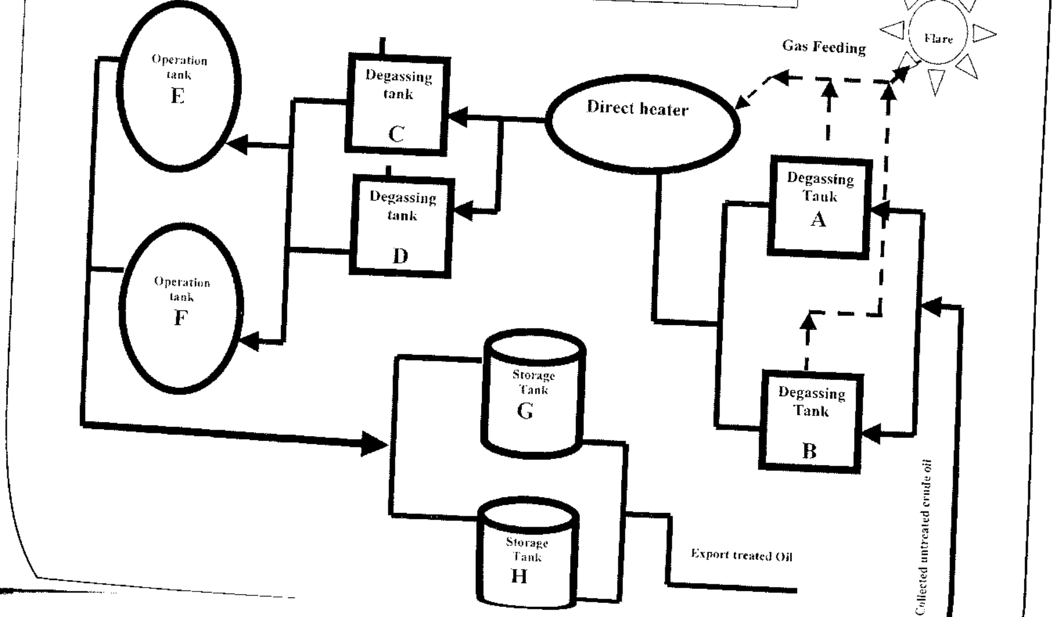
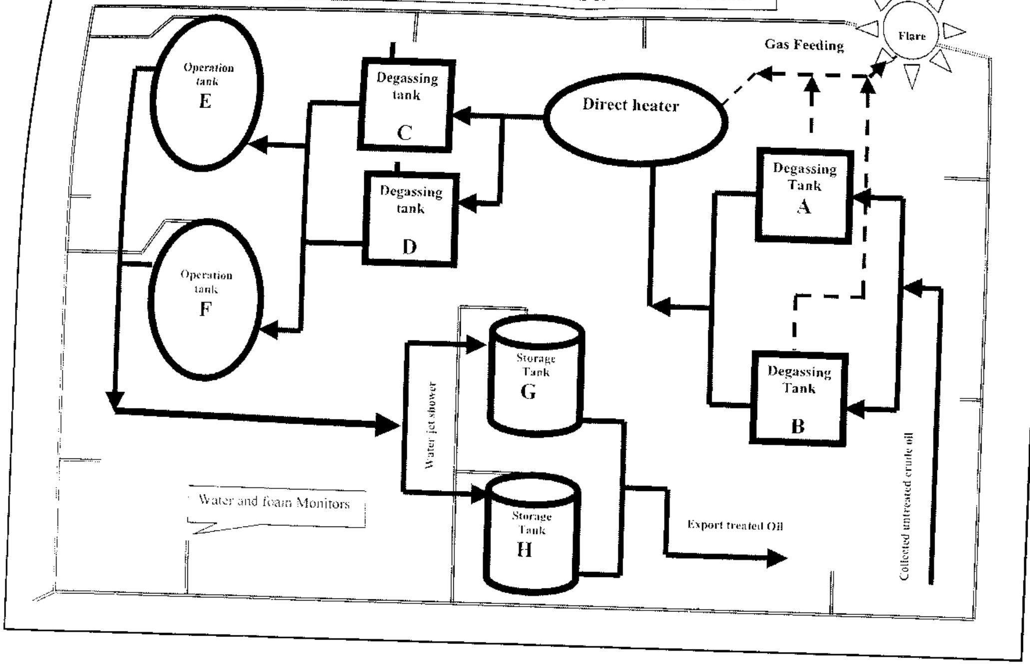


Fig. No. (3) Flow Diagram for Fire Fighting System of the Burned Plant



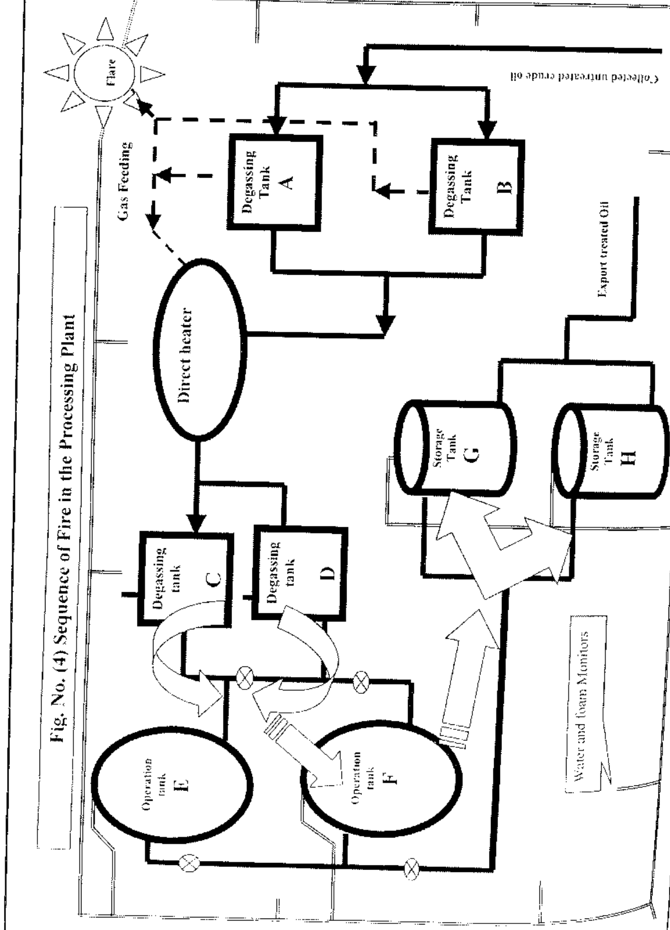


Fig. No. (4) Sequence of Fire in the Processing Plant

- One operational tank of 30,000 bbl capacity.
- Two storage tanks of 15,000 & 30,000 bbl capacity.
- One newly equipped firefighting car.
- One car equipped with a crane.
- The exterior of the administration building.
- Many tons of foam materials.
- Minor injuries for some firefighting personnel and serious injuries of two firefighting personnel.

Indirect losses

- Complete shutdown of the plant and the transfer of untreated crude oil to another treatment and processing plant.
- Cost of reconstructing an alternative, modern and secure processing plant.
- Cost of the cleaning and the rehabilitation of the polluted area.

Environmental damage

This accident also affected the environment in many ways. For example:

Black clouds, soot and fine dust were formed from the incomplete combustion of crude oil. These spread in the atmosphere and to the surrounding areas. The calm wind assisted the stagnation of the black clouds and reflected a feeling of suffocation and darkness for several days after the fire had ended. Fortunately, the burned plant was in the desert far from urban areas (the nearest city was almost 40 km away).

A wide area of soil, both at the plant's location and in the surrounding terrain (about 7.5 km2) was polluted with spilled crude oil. A huge number of vacuum trucks and heavy equipment were needed to remove and clean up the polluted area.

A wide area of the coast and seawater was also polluted with crude oil, which was drained from the storage tanks into the Gulf of Suez in order to starve the fire. The polluted seawater was encircled with a boom, skimmed, collected and pumped for re-treatment again.

Root and Contributing Causes of the Fire and Expert Analysis

Many investigations have been carried out by the police and other specialized authorities to determine the root causes of the fire. They concluded that the main cause of the fire was lightning. The other contributing causes included:

- Inefficient fire detection facilities (heat and smoke detectors), which was made worse by a delay in the alarm system.
- The failure of the equipment used to fight the fire.
- The delay in calling the highly equipped and professional firefighting teams (especially the armed forces' team).

Recommendations for Protection Against Lightning

There are two basic approaches to lightning strike protection, the remedial and the preventive. The remedial or collective approach is commonly used in the Russian Federation and Norway.

Remedial or collective option

It is designed to divert the stroke channel in order to function and achieve the following:

- Capturing the stroke leaders.
- Diverting all energy away from the equipment.
- Establishing a low impedance interface with the ground.
- Eliminating any secondary effects (electromagnetic fields).

Within all lightning stroke characters, the collective method depends on three main items:

- *Air terminal:* This determines the protected zone according to its height, in the form of a "cone of protection." Its head is located at the tip of the top terminal and then slips with an angle of 45° with the terminal, to form a base or radius equal to the terminal height. The efficiency would not exceed 90% if the terminal height is less than 100 meters.
- *Down conductor and ground conductor:* This is usually a length of open wire running from the air terminal to the earth. The resulting impedance can vary from 500 to over 5,000 ohms, depending on the physical parameters. The average lightning current rises at the rate of 100,000 ampere per microsecond. This rate represents a high impedance to a lightning current and will develop a voltage difference of over one million volts.
- *Grounding:* The grounding provides the protection for personnel against the electric shock. This is ensured by a common reference plan for the electrical circuit, a sink for lightning energy and a return for fault current in the power system. Grounding resistance could be a problem as grounding resistance of less than 1 ohm may be obtained by using individual electrodes connected together. Such a low resistance may only be required for large sub-stations or generating stations. Resistance in a 2-5 ohm range is generally suitable for industrial plant sub-stations, buildings and large commercial installations. A resistance of 25 ohm is the maximum resistance for a single electrode. If a higher resistance is expected more than a single electrode would be required.

The collector systems' drawbacks include secondary effects that relate to the close proximity of the electrostatic and electromagnetic fields. They can be dangerous to flammable items, explosives and electronics.

Preventive option

To prevent lightning strikes in a given area, a system is needed to reduce the potential between the specific site and the cloud cell.

Protection may also be achieved by tampering with the induced charge created. A lightning protection system would then reduce the charge induced by a strike of lightening, to a level that would make a lightning stroke impractical.

This is best achieved by installing a multipoint ionizer as a dissipation device. As the potential for a lightening stroke increases, the ion current would also increase exponentially.

The electrostatic field created by the storm cell will then draw the charge away from the site, leaving that site with a lower probability of a lightening strike than its surroundings.

The dissipation array system consists of three basic elements, the dissipater (or ionizer), a ground current collector and service wires.

The protection of storage tanks

Tanks containing flammable and combustible liquids, or gases stored at atmospheric pressure can be set on fire by a lightning strike. A direct hit would ignite the vapors that escape from the tank and this may then cause a fire on the upper surfaces of the wood-roof tanks.

Externally ignited vapors may carry flames inside the tank. This could then result in an explosion or a fire if the tank contains a mixture of flammable or combustible air vapor.

The tanks situated above ground storing flammable or combustible liquids or gases, are at present thought to be protected against lightning as they are made out of carbon-steel.

However the following are also necessary:

- All joints between steel plates should be riveted, bolted or welded together.
- All pipes entering the tanks should be metallically connected to the tank using isolating flanges.
- All vapor openings should be closed or protected using flame arrestors.
- The tank and the roof should be constructed using a minimum of 3/16 inches thick steel sheets. This would ensure that a lightening strike would not be able to penetrate the roof of the tanks.
- The roof should be continuously welded, bolted or riveted to the body of the tank. It should also be caulked ensure that all seams are vapor-tight. The tanks should also be securely earthed.

Recommendations

- Meteorological maps and thunder distribution should be reviewed.
- There is a greater need for lightning protection of crude oil storage tanks (with a

fixed or a floating roof) and for periodic inspections to be carried out of all rim seals.

- All equipment, tanks, vessels and buildings should be securely grounded. The control room should also carry out periodic measurements, and regularly review and renew all resistance records.
- All processed steel structures should be protected against lightning, making sure these structures are connected and earthed to the overall network.
- There should be rigorous fire prevention and protection measures installed in all plants. These safety regulations have to be based on laws, municipal legislation and technical recommendations. The fire prevention regulations are usually drafted in one of two forms, in detail or by reference. These safety regulations should be revised periodically by the Civil Defense Authorities, to ensure that they are kept up to date. All oil and gas plants should have reliable, operational and well-designed fire and gas detectors, instantaneous alarm systems and fire extinguishing systems. These safety and operational procedures should be taught to and practiced by all personnel at the plant.
- There is little need for fixed roof tanks for petroleum products if all heating and venting points are equipped with working flame arrestors. However, it is possible to enhance the protection of floating roof tanks (oil storage tanks) through the installation of wire-mesh panels along the external circumference of the tanks.
- There should also be cable land terminations in all control cubicle bodies. These should also be joined to the grounding network.
- It is recommended that clean and dirty earth is mixed together, or that spark gaps are properly maintained within the digital control system (DCS).
- The installation of a local lightning air termination may be necessary to protect valves and vents on the top of the tanks and process vessels, through the installation of steel rods well connected to the grounding network.
- It is advised that there should be a metallic structure for the control room including the proper grounding of the building.
- Telecommunication links connecting the high towers to the nearby control room should be protected, and the conductivity of the metallic structure should be maintained and well grounded.

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Common Ground on Chemical Risk:
Case Studies from the Middle East

Common Ground on Chemical Risk: Case Studies from the Middle East is the final product of a collaborative research project of the Chemical Risks Consortium, formed by non-governmental organizations in Egypt, Israel, Jordan, and Palestine. Each case study provides a detailed look at a chemical incident, highlighting country-specific mechanisms in responding to chemical and environmental hazards posed by industrial or commercial services. Throughout the analyses of the strengths and weaknesses of their respective national capabilities runs the underlying assumption that the Middle East as whole remains vulnerable to chemical incidents, whether accidental or deliberate, irrespective of borders. The Chemical Risks Consortium and its projects were born of the recognition that the region is unprepared for effective collaboration in the face of any catastrophic phenomenon that could affect every country in the Middle East, and that practical cooperation in technical fields serves the dual use of building regional capacity and building bridges of confidence between nations.

The CRC is convened by Search for Common Ground, an international conflict transformation organization that strives to move conflicts away from adversarial approaches and towards cooperative solutions. In the Middle East, Search for Common Ground looks beyond the conventional approaches to peace-building, seeking to bring partners together in previously unexplored areas of mutual concern.