

Second Quarter 2017 Issue No. | 26

enviro news

Environmental Protection Department Newsletter



Photo Source: Saudi Aramco





Environmental Protection Department

Manager – Omar S. Abdulhamid

Enviro News Editorial Board

Chairman – Mohammad Othman

Khaled Abdulkader

Salim Khasawinah

Abdullah Alsuhainy

Francisco Estevez

Mohammad Hajri

Ziad Hawi

Khalid Binali

Abdullah K. Tawlah

Hussain Aseeri

Forrest Jones

Umar Zahrani

For any questions, comments or any other inquiries regarding Enviro News, contact **Forrest Jones** at alfred.jonesiii@aramco.com or at 013-880-9845.

A Message from Omar S. Abdulhamid, EPD Manager

Welcome to Issue #26 of Enviro News. In this edition, you'll see more examples of how Saudi Aramco protects the Kingdom's environment, from its natural resources and vast biodiversity to the health of its communities, employees and their families.

The company's air quality, marine, waste management and water conservation programs continue advancing to reduce our environmental footprint. In this issue, we'll explore how inspectors are relying on bioavailability to analyze risks that pollutants may pose on ecosystems. What is bioavailability? Bioavailability refers to the level a substance must reach until it becomes available for intake by organisms. We'll also examine how the company incorporates safety and performance measures into flare and relief systems. Ensuring air quality is a key aspect of Saudi Aramco operations as is ensuring the safety of all those on the job while protecting the environment at the same time. Conserving resources at all times is crucial to Saudi Aramco's business, and that includes our most precious resource of all, our people.



In fact, protecting worker and community health extends far beyond our oil and gas facilities. Much effort goes into making sure the foods we eat and the water we drink at home are safe and sound for you and your family. To do just that, we conduct numerous health and safety inspections of dining facilities, restaurants and all other locations where food and drink are sold and consumed on company property, with oversight extending outside to include our vendors as well. Rest assured the company has done its part, but know you can do your part as well, especially when away from Saudi Aramco premises. In this issue, learn how to avoid salmonella from a food staple across the planet — the egg. Also read more to learn how salmonella and other illnesses may be prevalent in less obvious places, such as on a cutting board used to sort parsley.

Protecting your health, meanwhile, extends beyond the dinner table and into the office. Poor posture can lead to the development of Musculoskeletal disorders. Muscles, tendons, ligaments, nerves and blood vessels are at risk and may subject you to stress and pain due to improper sitting, typing and other office positions. Not all work-related injuries stem from heavy lifting or other physically strenuous activities. Sitting too long can take its toll on your health. Learn more about how to ensure a healthy day at your desk.

This edition of Enviro News also provides an update on the Shaybah Wildlife Sanctuary, officially inaugurated by Saudi Aramco's Board of Directors in December of 2016. From an ecological perspective this achievement is extremely important for the company and the Kingdom. Reintroducing one large-bodied species into the wild is not easy, let alone three like Saudi Aramco has done.

Lastly, no company success stories become reality without the support of their people. In this issue, we'll look back on those departments awarded for environmental excellence this year, a task that can only materialize with the commitment from everyone. We'll also review EPD's accomplishments at overseas environmental events in the magazine's In Focus section.

So welcome to Issue #26 of Enviro News. As always, I look forward to hearing from you and learning more about your environmental news and accomplishments in future editions of the magazine.

Table of contents

Environmental Protection Department Newsletter

Second Quarter 2017 Issue No. | 26

Horizons	01
EPD honors four departments at the President's Excellence Award 2017 ceremony	02
The Biodiversity Benefits of Shaybah Wildlife Sanctuary	04
A Look at Work-Related Muscoskeletal Disorders	08
Keeping a Healthy Food Staple Healthy-the Egg	12
Keeping Salmonella at Bay in Your Kitchen	14
In Depth	17
Safety Measures in Flare System Design and Operation	18
Risk Assessment from a Biodiversity perspective	24
In Focus	29
Smithsonian's "Movement of Life" Comes to Saudi Arabia	30
Enviro Snaps	35
Rock Star: The Anderson's Rock Agama	36

Horizons



Photo Source: Saudi Aramco

EPD honors four departments for environmental excellence

› Forrest Jones, EPD

The Environmental Protection Department (EPD) co-hosted the annual President's Excellence Awards on May 24, 2017, honoring four departments in its category. The ceremony took place in collaboration with the Operational Excellence Department, Loss Prevention Department, Maintenance & Reliability Department and Corporate Affairs.

"Today, we bring these awards together under the umbrella of a

companywide pursuit of excellence," Amin Nasser, president and CEO, told attendees of the recognition event at the Plaza Conference Center, according to The Arabian Sun.

"What these groups share in common is that for each of them, excellence is more than a set of yearend results. It's more than a destination, it's a journey."

During the event, four departments listed here in no particular order of rank — Khurais Producing

Department, Riyadh Refinery Department, Southern Area Well Completion Operations Department and Manifa Producing Department — were recognized for their superior performance in protecting the environment and community and worker health in 2016.

The predecessor for the President's Excellence Awards — the President's Award for Environmental Excellence — was established in 2003 to recognize those individual facilities

For Operating Organizations:



Khurais Producing Department (Photo Source: Saudi Aramco)

For Operating Organizations:



Riyadh Refinery Department (Photo Source: Saudi Aramco)

For Service Organizations:



Southern Area Well Completion Operations Department
(Photo Source: Saudi Aramco)

Most Improved Organization:



Manifa Producing Department (Photo Source: Saudi Aramco)

and organizations that achieve superior success in protecting the environment. The first awards were presented in 2004.

The basis for the President's Award dates back to 2000 when EPD, through a study, looked at what

other oil companies were doing in this area. The study recommended that Saudi Aramco provide incentives for its organizations to improve efforts in protecting the environment. EPD determined that the most appropriate way to compare

organizations was using a balanced scorecard approach. Therefore, the Corporate Environmental Scorecard, or CES system, was established. Establishment of the CES system was followed by the development of the Facility Environmental Performance (FEP) system as a means to assess and rank Saudi Aramco organizations based on their accomplishments in four environmental categories: Performance, Compliance, Awareness & Training, and Initiatives. Over 50 organizations are currently included in the FEP system, which includes a number of measures to assess company organizations in several environmental areas considered important to environmental performance. Measures are grouped under the four categories and evaluate areas such as air quality, groundwater protection, wastewater management, oil spills, surveys and assessments, environmental initiatives, and awareness and training.

Organizations under the FEP are scored and ranked using environmental data. This is collected by EPD through various environmental programs and systems including comprehensive environmental assessments. Each of the four environmental categories has a maximum number of points, based on the significance of each category. Each category is assigned a maximum number of points as follows:

Compliance	30
Performance	30
Initiatives	25
Awareness & Training	15
Total Points	100

The biodiversity benefits of Shaybah Wildlife Sanctuary

› Chris Boland, EPD

In December 2016, Saudi Aramco's Board of Directors officially inaugurated Shaybah Wildlife Sanctuary. This article explains from an ecological perspective why this is such an important achievement for the company and the Kingdom.



Company directors attend an inauguration event at the Shaybah Wildlife Sanctuary. (Photo Source: Saudi Aramco)



First Arabian Sand gazelles released into Shaybah Wildlife Sanctuary. (Photo Source: Saudi Aramco)

The majestic Rub' al-Khali wilderness

There are three reasons why Shaybah Wildlife Sanctuary is special.

First of all, Shaybah Wildlife Sanctuary is special because the Rub' al-Khali itself is special. For example, after searching the planet, a global NGO called Conservation International declared that there are only 37 areas of true wilderness left on earth. Only 37. These include such places as the Antarctic Peninsula, the New Guinea Highlands and the Serengeti Plains. One of these last true wildernesses is the Rub' al-Khali Desert, and yet 0% of the Rub' al-Khali was formally or physically protected, until now.

By constructing a fence 104 kilometers long Saudi Aramco has protected 637 square kilometers of internationally acclaimed desert

wilderness. We have created one of the largest fenced nature reserves in the world, and certainly the largest fenced nature reserve ever built by an oil and gas company.

To put the extent of this achievement into perspective, Shaybah Wildlife Sanctuary is about the same size as the entire country of Bahrain. Indeed, there are 18 countries smaller than this sanctuary. Make no mistake, this is a protected area of global significance.

Protecting a surprisingly diverse ecosystem

The second reason why Shaybah Wildlife Sanctuary is special is because of the extraordinary array of unique and threatened biodiversity that it protects, including 10 bewildering

plant species that are able to withstand some of the most extreme conditions on earth. Furthermore, studies reveal that as many as 13 native reptile species, 18 mammal species, and a staggering 176 bird species might also occur within the fenced area.

In total, 217 species of plants and animals are potentially protected by Shaybah Wildlife Sanctuary (not to mention an inestimable number of invertebrate species, some of which could be new to science). The sanctuary is likely to protect 19 species that occur only in the Arabian Peninsula. Indeed, five species occur only in the Rub' al-Khali and nowhere else on the planet, namely two mammals (Rub' al-Khali Hare and Arabian Jird), one reptile (Oman Agama) and two plants (Hādh and Hārm)



The ostrich (Photo Source: Saudi Aramco)

Therefore, this sanctuary helps to align the company with several UN Conventions on conserving biodiversity. Shaybah Wildlife Sanctuary aligns with the UN Convention on Biological Diversity, for example, by protecting 39 species that the Saudi government has listed as being of national conservation priority, 40 species that are formally listed as internationally threatened or near threatened, and 92 species that are decreasing internationally. In addition, the sanctuary aligns with the UN Convention on Conserving Migratory Species by creating a safe haven for a whopping 169 migratory bird species that potentially pass through on their epic annual journeys between their African foraging grounds and their breeding grounds across Europe and Asia. Importantly, Shaybah Wildlife Sanctuary protects

many species that are not formally protected anywhere else on the earth.

Clearly, this sanctuary is a great step forward for biodiversity protection in Saudi Aramco, Saudi Arabia and indeed the world.

Return of the oryx, gazelle and ostrich

The third reason why this sanctuary is special is, of course, the reintroduction of three animals that had recently disappeared from the ecosystem: the Arabian oryx, the Arabian sand gazelle, and the ostrich. These three species were selected to be reintroduced to Shaybah because they all previously occurred in Shaybah. All three species, including the ostrich, occurred at Shaybah in historic times. Many people do not realize that ostrich are native to

Arabia. In fact, we still find ostrich eggs in Shaybah that were laid 100 years ago but never hatched.

We brought these animals to Shaybah not merely for display—we brought them here because they belong here. They have always been regarded as a very special part of this landscape. In fact, the oldest remaining archaeological structures in Arabia are huge, 12,000 year old stone traps built into the landscape to catch oryx, gazelle and ostrich. The oldest pieces of art in Arabia are 10,000 year old rock etchings that depict oryx, gazelle and ostrich. Similarly, the oldest known poetry in Arabia (the famous 1,500-year-old mu'allaqat) also depicts oryx, gazelle and ostrich. Even today, many Saudi women are called Maha or Reem, the Arabic words for oryx and gazelle, respectively. Clearly, these animals are of great cultural

significance to the region.

Unfortunately these striking animals were decimated by 20th Century hunting. In 1939 the last ostrich in Arabia was shot. The gazelles all but disappeared soon after. And so did the oryx. Almost. By 1972 there were only four individual oryx left in the wild ... Four.

Thankfully, the world's conservation community mounted an urgent heroic rescue attempt to save the oryx from extinction. After all, this is the species that the unicorn myth is based on.

Helicopters were brought in to catch the last animals—and they got all four of them—not far from Shaybah actually. Fortunately the King of Saudi Arabia had a couple in his private collection, as did some of our neighboring countries within the Gulf Cooperation Council. In total there were nine oryx left in the world. And that was all.

These nine animals became known as the World Herd. In the 1970s they became international news that captivated global attention. The famous World Herd were cautiously shipped to Phoenix Zoo in Arizona where they were carefully bred up, and in time they were slowly returned to Arabia. And now perhaps 3,000 are alive today.

The Arabian oryx is the only animal in history, anywhere in the world, that has recovered from being formally listed as 'Extinct in the Wild' up to 'Vulnerable' (skipping above the more ominous categories of 'Endangered' and 'Critically Endangered'). It is the only animal to have gone that close

to extinction without actually toppling over into the abyss. Consequently it is the symbol of hope for the global conservation movement. Indeed, the leading international conservation journal is now simply called 'Oryx' in its honor.

Now Saudi Aramco's name is associated with this heroic rescue effort. At the time of writing, we have 39 descendants of the World Herd, including 13 juveniles born in Shaybah in recent months. We also have 11 ostrich (which have laid dozens of eggs that are about to hatch), and 68 gazelle, including 14 babies "made in Shaybah". We are determined that these majestic animals will not go extinct. Not on our watch.

By 1972 there were only four individual oryx left in the wild ... Four.

The Saudi Wildlife Authority generously provided Saudi Aramco with these magnificent animals and continues to share decades of expert advice as part of its tireless efforts to protect biodiversity within the Kingdom. The project has benefited enormously from the authority. Further, the Company has enlisted the help of the Royal Society for the Conservation of Nature in Jordan to oversee the daily management and welfare needs of the animals and ecosystem at Shaybah.

Looking to the future

To help ensure the ongoing protection and restoration of Shaybah's vast wilderness area, Saudi Aramco is developing a research station to support national and international academics to help us better understand and manage this awe-inspiring landscape. The sanctuary has already received visits by distinguished desert ecologists from world leading arid research centers, including the Saudi Wildlife Authority (KSA), King's Park Botanic Authority (Australia), the Smithsonian Institute (USA), and Tottori University Arid Land Research Center (Japan), all of which are eager to establish academic projects at Shaybah.

Further, a visitor's center is being developed to help inspire and inform all of those lucky enough to visit Shaybah. After all, research and education are the most important tools of conservation biology.

In conclusion Shaybah Wildlife Sanctuary is not a mere zoo display of oryx, gazelle and ostrich. It is a complete biodiversity protection and restoration area that preserves one of the world's truly great wildernesses and helps to restore some critical components of Saudi Arabia's natural and cultural heritage.

So on behalf of the plants and animals in Shaybah Wildlife Sanctuary and future generations of Saudi Arabians, the Environmental Protection Department extends a sincere thank you to the Board of Saudi Aramco for supporting this historic achievement.

Work-related musculoskeletal disorders. are you paying attention to your posture?

› Ahmad Qahtani, EPD

Not all injuries on the job result from what one would assume are the usual suspects (e.g., falling or getting cut or burned, etc.). Your plush office chair can cause you pain if you let it, as poor posture can lead to work-related Musculoskeletal disorders (MSDs), which cost companies and economies dearly.

So what are MSDs anyway? According to the Canadian Centre for Occupational Health and Safety, working in awkward postures or with excessive effort, fatigue and discomfort may affect our muscles, tendons, ligaments, nerves and blood vessels. These kinds of injuries are known as work-related MSDs. Improper posture, awkward or repetitive movements can damage muscles, tendons or nerves

Common work-related MSDs include:

- › Lower Back Pain
- › Muscle Strain
- › Tendonitis
- › Carpal Tunnel Syndrome
- › Rotator Cuff Syndrome
- › Tennis Elbow
- › Shoulder Pain
- › Tension Neck Syndrome





Lower back pain, carpal tunnel syndrome and tension neck syndrome are examples of work-related Musculoskeletal disorders. (Imagery Source: Alaniz, 2009)



MSDs can increase the cost of doing business both directly, such as medical services and higher compensation, and indirectly, such as employee turnover, absenteeism and retraining. It has been proven that productivity, quality and employee morale can be negatively affected too, according to California Occupational Safety and Health Administration (Cal-OSHA).

OSHA estimates that work-related MSDs in the United States account for roughly 34% of all lost workdays reported, which is roughly 600,000 injuries and illnesses. Employers spend as much as \$20 billion a year on direct costs for MSD-related workers' compensation, and up to five times that much for indirect costs (Prevention of Work-related

Musculoskeletal disorders, 2014).

Risk of MSDs

The risk of succumbing to work-related MSDs depends on these risk factors as indicated by the Canadian Centre for Occupational Health and Safety:

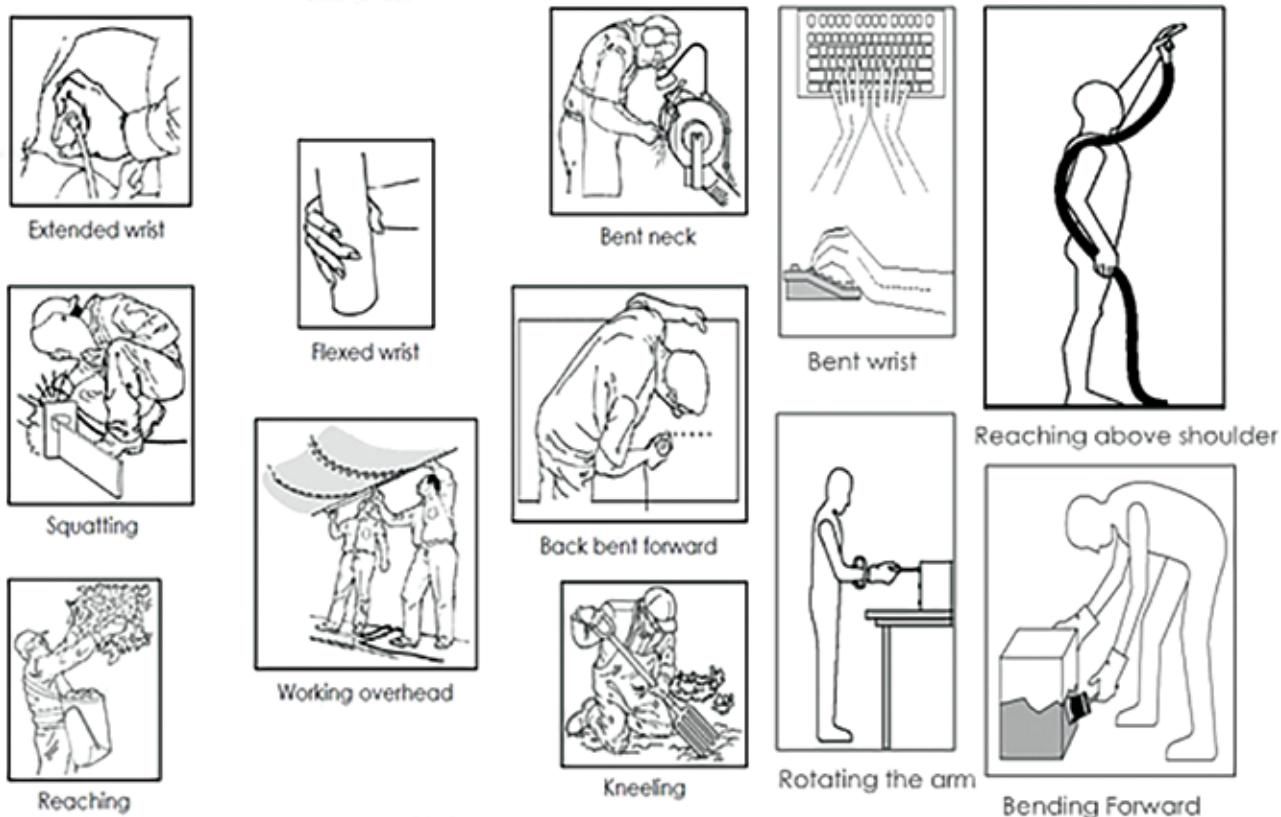
- Work postures and movements
- Repetitive work
- Force of movements
- Vibration
- Temperature
- Lack of or poor communication

Common awkward postures

Working in shops, operations, offices and other facilities within Saudi Aramco or in any work environment can create stress on the musculoskeletal system. Paying attention to awkward posture in specific tasks or jobs can help you avoid MSDs. The drawings on page 10 illustrate examples of poor posture during work.

Even sitting at a desk can result in a work-related MSD if posture remains poor. To avoid developing work-related MSDs, the Environmental Health and Safety Department at the University of Chicago recommends the following:

- Select tools allowing neutral postures



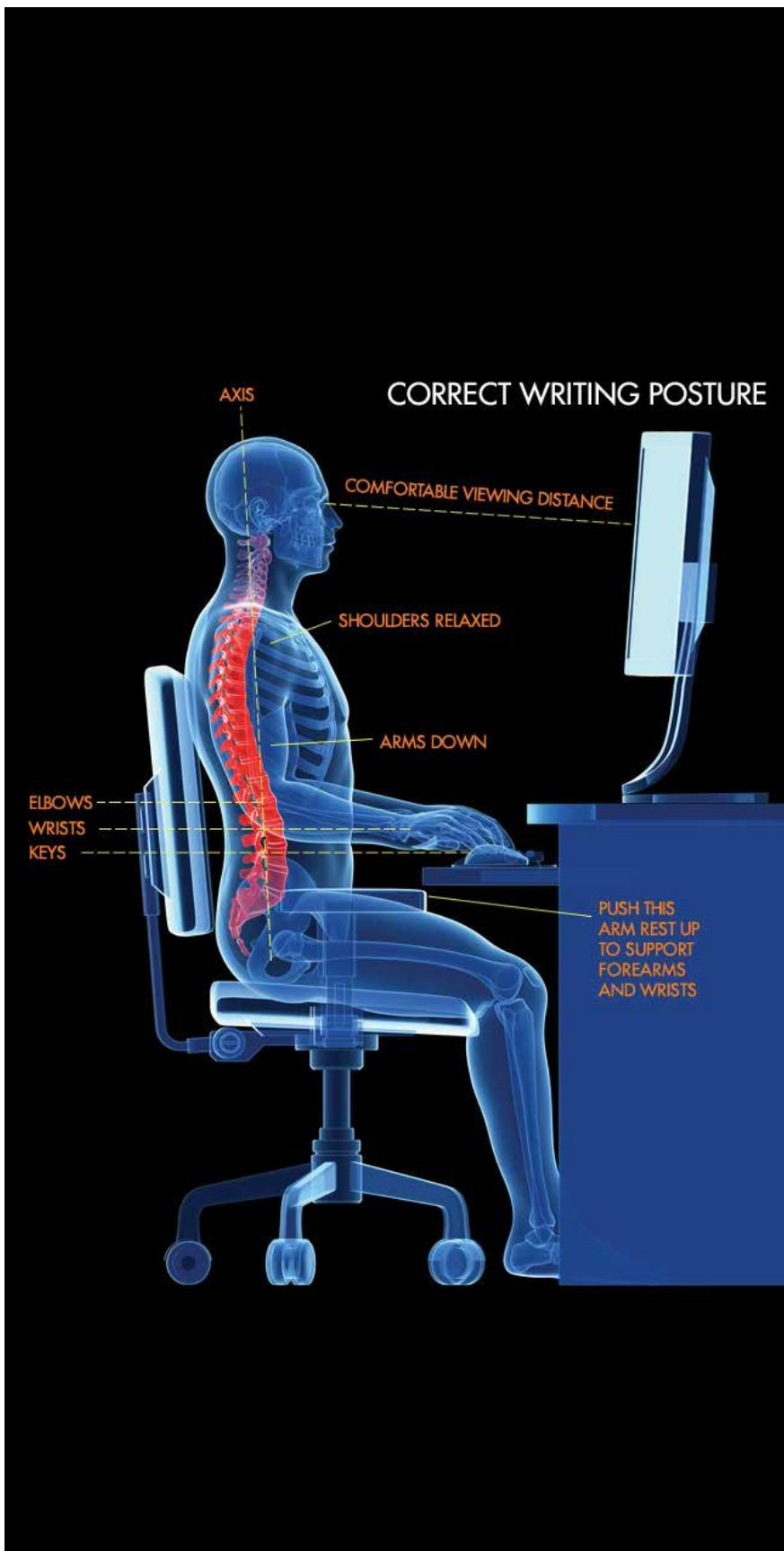
Various body actions that can result in MSDs.

(Imagery Source: University of Chicago, Environmental Health and Safety)

- Utilize adjustable workbenches and chairs
- Use lifts to avoid bending over
- Use step stools or ladders to avoid reaching overhead
- Perform work at the proper heights
 - Above the elbows for precision work
 - At the elbows for light work
- Between the waist and elbows for heavy work
- When awkward postures cannot be avoided
 - Limit the duration in the posture
 - Take regular breaks
 - Perform a variety of jobs to change postures
 - Complete forceful actions in as neutral a posture as possible

Correct office posture

A large number of Saudi Aramco employees spend a majority of their time on workstations and thus, their risk of work-related MSDs may be higher than they think. Just because a day's work isn't on the rig or refinery but in a cubicle instead doesn't mean the possibility of a health condition isn't there. You can improve your wellbeing by maintaining neutral posture such as standing, declined



A likeness illustrating correct writing posture. (Imagery Source: Bricker, 2015)

sitting, upright sitting and reclined sitting.

To conclude, you only have one body, so take care of it. That includes posture, too. Good posture is a must at all times, from heavy lifting to a heavy workload at the computer. Musculoskeletal disorders are serious and can result even when sitting improperly at a desk. They can cost you physically and financially as well, even affecting your job performance. So lift the legs, sit up straight and type correctly to enjoy a healthy work environment.

References

Alaniz, R. (2009, November). How to Spot and Avoid Potential Ergonomic Injuries. Retrieved from Work Truck: <http://www.worktruckonline.com/channel/safety-accident-management/article/story/2009/11/how-to-spot-and-avoid-potential-ergonomic-injuries/page/1.aspx>

Awkward Posture- Safety Talk. (n.d.). Retrieved from The University of Chicago. Environmental Health and Safety.: <https://safety.uchicago.edu/files/Awkward%20Postures.pdf>

Bricker, D. (2015, February 16). Writing Ergonomics: Avoiding Injury at Your Desk. Retrieved from The World Greatest Book: <http://theworldsgreatestbook.com/writing-ergonomics/>

Canadian Centre for Occupational Health and Safety. (2016). Work-related Musculoskeletal disorders (WMSDs) - Risk Factors. Retrieved from OSH Answers Fact Sheets: <http://www.ccohs.ca/oshanswers/ergonomics/risk.html>

Sunny side down. a hardboiled look at avoiding disease with a food staple: the egg

› Majed Arf, EPD

How do you take your eggs? Scrambled? Fried? Or do you just use them as ingredients in your favorite recipes? Whatever the case, only the eggshell should end up shattered and not your health. People across the globe eat eggs on a regular basis. Still this otherwise nutritious staple may pose health risks.



Properly refrigerated eggs as seen here can protect you from salmonellosis or E. Coli. (Photo Source: Saudi Aramco)

Salmonella infection, or salmonellosis, is a bacterial disease of the intestinal tract. Salmonella is a group of bacteria that causes typhoid fever, food poisoning, gastroenteritis, enteric fever and other illnesses. People become infected mostly through contaminated water or foods, especially meat, poultry and eggs. Even though eggs may look clean, salmonella may be present not only on egg shells, but also inside the egg. A person infected with Salmonella may experience fever, abdominal cramps, diarrhea, and sometimes vomiting beginning up to 72 hours after consuming a contaminated food or beverage. The illness usually lasts four to seven days, and most people recover without treatment. High-risk groups including the elderly, infants, pregnant women and immuno-compromised patients are particularly vulnerable. If you experience food poisoning symptoms, seek immediate medical advice as dehydration can be life-threatening.

In 2009, the U.S. Food and Drug Administration unveiled regulations, which many adopt worldwide, to curb approximately 79,000 cases of foodborne illness and 30 deaths caused each year by consuming eggs contaminated with the bacterium Salmonella Enteritidis. The regulation requires preventive measures during the production of eggs in poultry houses, such as subsequent refrigeration during storage and transportation at a temperature not to exceed 45 °F (7 °C). Saudi Aramco's environmental health inspectors make sure all foods and beverages consumed on company premises are safe and

sound, and eggs are no exception. The Environmental Protection Department's (EPD) Environmental Health Unit covers the process from farm to fork by monitoring approved egg farms as well as all Saudi Aramco food establishments who handle eggs such as diners, snack bars and commissaries. Inspectors check for the implementation of Food Safety Management Systems in order to ensure hygienic storage and handling of eggs.

Still, consumers must do their part. To avoid succumbing to food poisoning, follow the guidelines below regarding proper egg handling:

- Buy eggs only from stores or other suppliers that keep eggs refrigerated
- Open the carton and make sure that the eggs are clean and the shells are not cracked
- Keep eggs refrigerated at home
- Observe expiration dates
- Disinfection is recommended along with washing hands, cutting boards, dishes, utensils and counter tops with hot, soapy water after contact with raw eggs
- Eggs should be thoroughly cooked until both the yolk and white are firm
- Consume eggs promptly after cooking. Do not keep cooked eggs warm or at room temperature for more than two

hours

- Beware of food containing raw or lightly cooked eggs such as cookie dough, homemade mayonnaise and Hollandaise sauce. High risk groups should refrain from consuming raw or undercooked eggs or egg containing food.

References

U.S. Food and Drug Administration, US.<http://www.fda.gov/Food/ResourcesForYou/Consumers/ucm077342.htm>

Centers for Disease Control and Prevention, US. <http://www.cdc.gov>

Health Protection Agency (2011) Salmonella, UK. http://www.hpa.org.uk/web/HPAweb&HPAwebStandard/HPAweb_C/1195733816528

Go aboveboard. disinfect your cutting boards on top of washing to avoid cross-contamination

› Ziad Hawi, EPD

Mention the word "Salmonella" to most people and images of undercooked chicken come to mind. Ask anyone who has been inflicted with the insidious bacteria, and you'll

quickly discover they'll do anything to avoid it. So make sure your food is properly cooked, right? Yes, but that's not enough. According to new research using cutting boards as a

testing ground, washed produce can still transmit the disease if risky surfaces are not duly disinfected.



(Photo Source:Saudi Aramco)



Properly disinfected cutting boards, whether used for vegetables or meats, can protect against disease. (Photo Source: Saudi Aramco)

The identification and prevention controls of physical, chemical and microbiological hazards are essential requirements in food safety. In this context, food-industry compliance with temperature requirements and the application of adequate sanitation measures are critical elements to preventing the growth of microorganisms and food contamination. Still, there's another factor that merits equal attention: Cross-contamination. Cross-contamination involves the transfer of harmful bacteria to food from other foods, cutting boards, utensils, etc. Cooking your food well might not spare you food poisoning if you prepare the contaminated food on a cutting board and then use that same surface to cut vegetables for a salad. Cross-contamination has been implicated in a number of food poisoning cases, which has led many researchers to investigate the conditions and the complex factors that support the transfer of bacteria and to determine effective risk

mitigation measures.

According to the authors of a recent study (Faour-Klingbeil et al., 2016), food poisoning outbreaks are not limited to contaminated foods of animal origin, but rather, they are increasingly linked to consumption of fresh produce, including parsley and lettuce. There are various routes for cross-contamination and recontamination, and cutting boards were shown to represent critical risk factors. In view of the scarce information on cross-contamination originating from plant sources and the fact that in many Mediterranean and Middle Eastern countries, leafy green parsley is typically eaten raw and prepared by fine-chopping several batches (Faour-Klingbeil et al., 2016). Researchers investigated the transfer rate of *Salmonella* Typhimurium, a strain of the bacteria, in scenarios that resemble normally occurring operations in restaurants and home kitchens. In their work, the authors aimed to quantify the transfer

rate of *Salmonella* from one originally contaminated bundle of parsley across all chopped batches. The importance of their investigation lies in the fact that *Salmonella Enteritidis* and *Salmonella Typhimurium* have been commonly isolated from fresh vegetables and that *Salmonella* spp. can be transferred to the food chain directly from human or animal fecal sources, run-off from nearby farms, untreated manure or from contaminated irrigation water. In their study, fresh parsley leaves were inoculated (artificially contaminated) with *Salmonella* and chopped on a polyethylene cutting board (CB). Afterwards, uninoculated (cleaned) parsley was sequentially chopped in individual batches on the same cutting surface in different groups:

1. One batch was placed instantly on the cutting board after chopping a contaminated batch (CB instant),
2. Another batch was placed on the cutting board after washing the surface in water and holding at 30 °C for 24 hours (CB WW).
3. A third batch was placed on the cutting board after washing the surface in soapy water followed by sponge scrubbing and holding at 30 °C for 24 hours (CB SW).

The results were eye opening, to say the least. They revealed a high transfer of bacterial cells to parsley chopped via CB instant and CB WW, recording values of 60% and 64%, respectively. *Salmonella* was readily transferred to the cutting surfaces and later was capable of contaminating chopped parsley instantly and at



Fresh parsley served as a testing ingredient in a study to determine cross-contamination scenarios involving cutting boards. (Photo Source: Saudi Aramco)

24 hours after washing the cutting board with water or soapy water combined with sponge scrubbing, with the ability to cross-contaminate every batch of parsley. Interestingly, considerable amounts of bacteria were transferred to six (6) sets of clean parsleys even when the contamination levels of parsley at the source was low. In other words, cleaning is not enough.

It was evident in the study that the density of bacteria can remain constant up to 24 hours supported by the abundance of nutrients. The authors suggested that the survival of *S. Typhimurium* for a prolonged time (24 hours) has been probably sustained by remaining substrates from parsley juice within knife-scars and fissures on the plastic boards' surfaces, which have been shown to be very difficult to clean and disinfect, although this may vary among the types of plastic cutting boards. Apparently, the simple domestic washing methods using

water and soapy water with sponge scrubbing reduced the transfer rate to all batches of parsley chopped subsequent to the contaminated samples on the same surface, but it did not effectively eliminate the risk of cross-contamination at instant and at 24 hours after exposure to bacteria.

The authors concluded that the application of additional sanitation procedures such as the use of a hypochlorite solution to disinfect should be a fundamental requirement, not only after the use of raw meat and poultry but also after chopping raw vegetables, especially those that may be destined for salads and are not further treated (ready-to-eat). Consumers should be aware of the increased likelihood of inadequate food safety measures at harvest and post-harvest stages.

EPD, as part of its Environmental Health programs, aims to eliminate foodborne hazards. The control of cross-contamination in food

processes is a major concern addressed in Environmental Health Inspections (EHIs) and Comprehensive Environmental Health Assessments (CEHAs). During field visits to catering facilities, EPD inspectors make sure that Food Safety Management Systems and related Standard Operating Procedures are carefully implemented by trained personnel. The Saudi Aramco Environmental Health Code (SAEHC) provides detailed guidance on the cleaning and sanitization of equipment and food contact surfaces. Paragraph 27 of Section 04 regarding food establishments details various procedures for cleaning and disinfecting utensils. This includes but is not limited to the use of a 100 ppm chlorine solution for a 30-second contact time or exposing food contact surfaces to heat at 77° C. Research results (Faour-Klingbeilet al (2016) provide clear evidence that vigilance in applying sanitation measures is key to eliminating cross-contamination hazards, and to providing safe food to consumers.

*This article was written in collaboration with Dr. Dima Faour-Klingbeil following her publication in the Journal of Food Research International that appeared in Science Direct. For more information, please refer to the original article, "The transfer rate of *Salmonella Typhimurium* from one contaminated parsley to other consecutively chopped batches," Faour-Klingbeil et.al. 2016 (<http://www.sciencedirect.com/science/article/pii/S0023643816304625>).*

In Depth



Photo Source: Saudi Aramco

Flared straight. safety environmental measures in flare system design and operation

› Adel Ghamdi, EPD

Introduction:

Measures and Topics Discussed in this article	
Safety Measures	Performance Measures
Relief Capacity (Adequacy)	Noise
Gas/Liquid Separation	Emissions from Flares
Heat Radiation from Flares	Smoke Mitigation & Control
Gas Dispersion	
Flashback Prevention	



(Photo Source: Saudi Aramco)

Environmental Protection Department Newsletter



Clear skies over Yanbu Refinery. (Photo Source: Saudi Aramco)

A fundamental activity in the oil and gas industry, flaring should — and can — take place in a manner that is as safe as possible. This article briefly describes the flare system's component and highlights its importance. It illustrates some key measures that should be followed to in order to improve safety and reliability during the design and operation of flare systems. The article is divided into two main sections: Safety Measures & Performance Measures.

Flare Systems

Flare Systems are designed to provide safe and effective disposal of gases and liquids at reasonable costs and with an environmentally compliant approach. They include all piping, valves, pressure vessels and devices downstream of the pressure relief point. Flare systems cannot be segregated from the pressure relief system as they must be viewed as

one integrated and comprehensive network.

Relief System

Systems of valves and piping are used during emergencies to rapidly reduce overpressure in process equipment via relieving to linked flare system components (unit header, main flare header and so on).

Several types of flare systems are available in the industry. Open barrel is the basic type (usually smoke-emitting). Air assisted, steam assisted, and high pressure sonic flares are types of flare-tip designs that achieve smokeless combustion of the effluent gases upon proper designs. Several industrial and environmental agencies mandate various regulations and standards to ensure proper handling and disposal of effluents to and from the flares. These key lines can be classified into safety measures and performance measures. The next

sections of this article will discuss a bit more on both types.

First: Safety Measures:

Flare & Relief Systems Capacity:

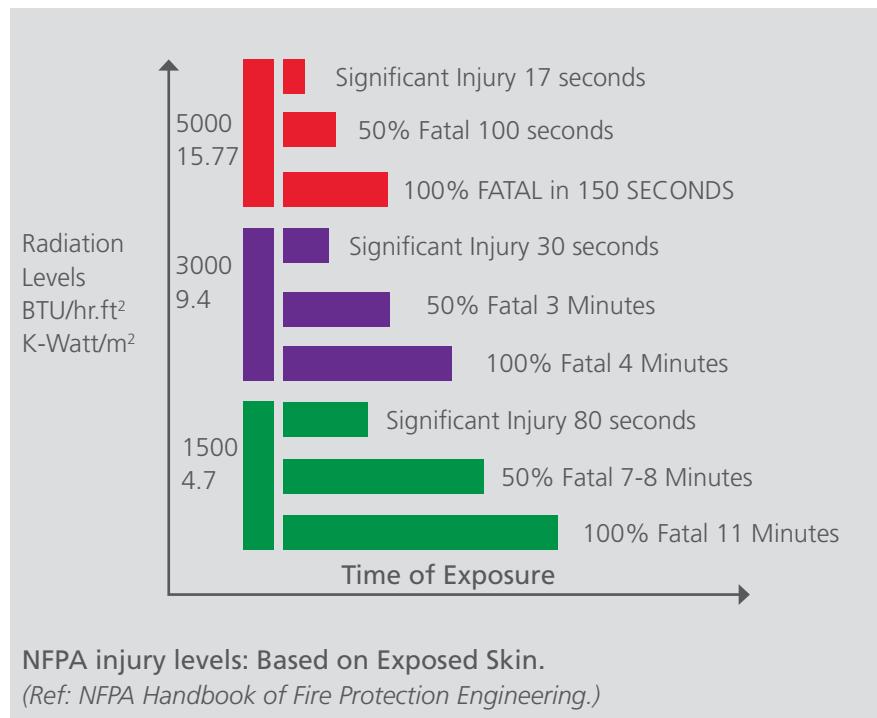
This is the first and most important safety measure. When designing a new flare system or retrofitting an existing one, it is crucial to ensure adequate relief capacity of all pressure relief valves for all credible relief scenarios. This relief capacity is a must due to the fact that excessive overpressure may result in unsafe conditions at the involved parts of the process unit (vessel, tower, and so on). The presence of undersized or oversized pressure relief valves could lead to possible explosions or even plant-wide damage. Proper sizing and selection of adequate pressure relief valves for process equipment is a critical and important task that requires great depth of relief-system

sizing and plant experience.

Flare and relief systems are viewed as integrated comprehensive networks in which a relief by multiple relief valves could impact some of those relief valves within the network. This impact is referred to as the backpressure effect. Excessive backpressure could result in obstructing the relieving capability of the pressure relief device at the relief source, variations in the openings or valve instability. In such situations, different solutions may be undertaken for mitigation. Examples include: upgrading the size and/or type of the pressure relief valve, modifying the pressure relief valve discharge piping in order to reduce the pressure drop, increasing the individual and/or main header(s) of the relief system, or even increasing the size of the flare main header line.

In Saudi Aramco, facilities are mandated to verify the adequacy of their flare and relief systems for all process plants. Conducting comprehensive relief audits for plants by experienced and specialized consultants is required to identify any undersized or overdesigned conditions and consequently identify optimum mitigation measure(s) as required. Various Saudi Aramco plants have already undergone comprehensive flare and relief systems audits in order to ensure their adequacy and consequently the safety of their facilities and personnel

Gas-Liquid Separation is another important safety measure that is normally achieved via the installation of a (gravity separation) knockout (K.O.) drum upstream of the flare



NFPA injury levels: Based on Exposed Skin.
(Ref: NFPA Handbook of Fire Protection Engineering.)

stack. K.O. drums are normally designed to separate liquid particles ranges from 300 to 600 microns in diameter from the gas going to the flare. Knockout drums shall have sufficient capacity to ensure residence time in excess of particle drop-out time based on the drop-out velocity required to remove particles larger than 400 microns. Usually, K.O. drums should allow a twenty-minute hold-up capacity of accumulated liquid in events of emergency relief.

In general, a well-designed knockout drum is essential to prevent liquid carry-over to the combustion zone at the flare tip. Liquid carry-over could result in liquid burning, liquid fire rain, or even liquid pool fires in severe cases. Additionally, poor combustion of such liquid particulates at the flare tip emits higher heat radiations and in parallel yields to excessive smoke due to incomplete combustion. A violation to the environmental smoke

emission regulations would also take place as a subsequent result of poor combustion.

Heat Radiation from flares is another important factor to worry about as a safety measure in flare design and operation. This is due to the fact that excessive heat radiation would injure personnel, damage equipment and structures. As a relative reference of heat radiation, it is suitable to mention here that a person would receive about 300 BTU/hr-ft² of heat radiation from the sun on bare skin on a sunny day (at about 35 °C). The National Fire Protection Agency (NFPA) has estimated the harm heat radiation could impose (the injury levels) on people (on exposed skin) as illustrated in the above chart:

NFPA reported that exposure to 1,500 Btu/hr-ft² of heat radiation would result in significant injury in about 80 seconds. Injury becomes 50% fatal if the exposure lasts seven to eight

minutes, and it would be 100% fatal if lasted for 11 minutes. The chart for the NFPA injury levels also illustrates that exposure to heat intensity of BTU/hr-ft² would yield to significant injury during the first 17 seconds. Prolonged exposure for a period of 100 seconds would be 50% fatal. Total fatality would result upon 150 seconds of exposure to heat radiation levels of 5,000 BTU/hr-ft². This figure clearly illustrates the seriousness of heat radiation impact on personnel and ascertains the need to implement all safety measures to protect people against flare heat radiation.

In fact, the issue of heat radiation exposure limits extends beyond the

concern of personnel exposure. Saudi Aramco standard SAES-F007: "System Design Criteria of Flares" specifies 5,000 BTU/hr-ft² (15.77 kW/m²) as the upper limit of radiation on the flare header, while 3,500 BTU/hr-ft² (11 kW/m²) is specified as the maximum limit on equipment and structures around the flare system. The location of a restriction fence around the flare zone is also mandated by the exposure limit for personnel. Saudi Aramco's recommended practice is to maintain the fence at 500 BTU/hr-ft² if the flare fence is accessible by the outside public.

Increasing the stack elevation is an option that may reduce the radiation

at grade to a compliance level. Changing the flare tip to a more efficient design (high pressure sonic) might also be an option to mitigate the heat radiation concern, but it is subject to the ability to meet the design requirement for high pressure flare systems.

Gas Dispersion is an important calculation used to estimate a downwind concentration of a gas vented to the atmosphere or emitted from a flare or a stack during flame-out. If a flare flame out took place, then the flare would fail to properly dispose toxic, corrosive or flammable vapors. This could pose critical health and safety hazards to personnel in the vicinity and the community downwind of the release. One possible released gas, Hydrogen Sulfide (H₂S), is the most dangerous substance affecting personnel. Gas dispersion analysis estimates the concentration of H₂S at grade level based on the analysis of multiple relieving scenarios, including overpressure cases. Consequently, the concentration of toxic material mandates safety design and operation regulations on the flare system to ensure safe working conditions. If we take hydrogen sulfide as an example, we would find that its density is 1.43Kg/m³ (at 20 °C and 1 ATM). This is 19% greater than the density of air at same conditions. Therefore, released H₂S would tend to fall at grade level and therefore would endanger the safety of personnel at such vicinities. The permissible exposure limit to H₂S is 10 ppm (parts per million). Short term exposure limit (for 15 minutes) is 15 ppm, and immediately dangerous to life and health threatening is 100 ppm, and

Maximum Onshore Flare Radiation Intensities for Personnel Exposure, Excluding Solar Radiation: (API-RP-521)

Flare Radiation		Conditions
KW/m ²	Btu/hr-ft ²	
1.6	500	Areas where personnel can be continuously exposed.
3.2	1000	Areas where personnel access shall be restricted (for onshore facilities).
4.7	1500	Areas where exposures up to several minutes may be required, with appropriate clothing.
6.3	2000	Areas where exposures of up to one minute may be required, with appropriate clothing.
9.4	3000	Areas where personnel have access, e.g., at grade below the flare, or on a service platform on a nearby tower. Exposure must be limited to a few seconds

Flaring exposure limits.

finally immediate death exposure level is 1,000 ppm. It is suitable to note that even low concentrations would build up in victim's lungs to reach to a deadly level.

Gas dispersion is also important to identify the lower flammability limits of the released hydrocarbons. It is important to ensure that the overall concentration of the released gases falls below the lower explosive limit of the gas mixture to avoid explosion. Technical Services Unit of the Loss Prevention Department in Saudi Aramco is the subject matter experts in carrying out gas dispersion analysis and providing further details on this subject.

Flashback Prevention: is essential to avoid rapid backwards burning of gases in the flare stack or flare header. Flashback could lead to explosion and damage to the flare system. It is usually a result of air ingress (infiltration) into the stack or even into the flare header. Air could enter through the stack outlet in large-diameter flare tips operating at low flaring rates with very low or no purge gas. It could also enter through leaks in piping or flanges or valves along the flare header. The solution to this is to maintain oxygen-free gas such as nitrogen to ensure maintaining a positive pressure along the header path to the flare tip. Also, piping and flanges should be checked against possible air leakage. On the other hand, the quantity of purge gas could be optimized through installing a liquid seal, a dynamic seals, a velocity or a molecular seal. Flame arrestors are also a solution to dissipate flame but Saudi Aramco does not allow using them due to

their potential plugging and also due to the big back pressure effect they could impose on some parts of the relief systems.

Second: Performance Measures

Noise is a by-product of flare operations. The main sources of noise are effluent combustion roar (especially in the event of high gas release and turbulent release: turbulence flow mixes faster with the air leading to bigger explosion and consequently louder noise), gas noise (in the event of high pressure flare), steam jet noise (in the event of steam assisted flare), valve and equipment noise (general in most flare types but noticeable more in staged flares), and blower noise (in the event of air assisted flare).

The U.S. Occupational Safety & Health Administration regulation 1910.95 obligates providing protection against the effects of noise exposure among workers when sound levels exceed those shown in the following table:

Permissible Noise Exposures: Per Occupational Safety & Health Administration 1910.95	
Duration per day (hours)	Sound level (dBA) Slow Response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

OSHA permissible noise level limits.

If personnel are subjected to sound

exceeding those levels listed in above table, then feasible administrative or engineering controls shall be utilized. If such controls fail, then personal protective equipment shall be provided and used to reduce sound levels to fall within the levels listed in the table.

Various techniques are available to reduce noise associated with flare systems. Most of them, however, begin with proper design. For example, installing mufflers or reducing the nozzle diameters are some common solutions for some types of steam-assisted flare.

Emissions from Flares: The first clear cut to observe emissions is seeing smoke associated with combustion. Continuous smoke emission is a sign of poor operation and/or poor design/flare tip condition. Usually, smoke is a result of unburned particulates of hydrocarbons. In countries where environmental regulations are more stringent, smoke emissions could lead to imposing sanctions, fines, and even possibly to a termination of operation permit in excessive and frequent cases. Other emitted particles from flares include Nitrogen Oxides (NOx), Sulfur Oxides (SOx), and, Hydrogen Sulfide (H₂S), and Carbon Dioxides (CO₂).

NO_x emissions are a concern because they contribute to the formation of acid rain. They lead to harmful effects on human health. SOx on the other hand include compound such as SO₂, SO₃, and SO₄. When SO₂ is released into atmosphere, it could produce acid rain by combining with water to form sulfuric acid (H₂SO₄), which is corrosive resulting in considerable



(Photo Source: Saudi Aramco)

damage on the environment.

One of the best solutions to reduce emissions is to implement a flare gas recovery system (FGRS), which enables capturing the routine daily flaring and compressing them back to the process.

Smoke Mitigation & Control is demanded based on community and environmental requirements. Usually smoke is formed when particulates of hydrocarbons burn without sufficient oxygen to complete the combustion. The intensity of the smoke is usually measured using Ringelmann Charts—physical observation of the smoke emitted from the flare and comparison to various black (screen-type) charts to measure the smoke intensity (opacity). Ringelmann charts are the simplest methods to estimate smoke intensity. The emitted smoke is proportional to the weight ratio of hydrogen to carbon in the compound being burned. Heavier hydrocarbons require more air to burn than lighter compounds.

There are several tools used to control or minimize smoke, such as injecting specified volumes or natural gas into the flare gas discharge headers, which eventually increases the heating value of the burned mixture and therefore improves combustion. On the other hand, the injection of steam is a second tool to boost smokeless combustion (steam assisted flares). Mixing with forced air is a third tool (air assisted flares types). Other tools include dividing the total load to the flare to multiple smaller flames (Multi-burners Staged Flaring). Elevated and grade mounted LRGO flares are good examples of multi-burner staged flare systems.

When the flare system has enough available pressure at the tip (generally above 15psig), then it becomes possible to utilize the available pressure (energy) in the gas to increase the mixing turbulence between the effluent gases and the surrounding air at the flare tip combustion zone. This concept is the fundamental requirement of high

pressure tips or sonic flare designs.

Conclusion: The importance of the flare and relief system for the safety of the plant should be clear by now. Incorporating and implementing all aspects of the mentioned safety and performance measures are essential keys to a reliable and a regulation-compliant flare operation. Not only the process operations, but also the safety of the plant personnel and the environment are accommodated upon compliance to these measures and other related ones.

At last it is important to realize the responsibility of designing, optimizing and securing the safety of the last-line-of-defense in oil, gas, or petrochemical plants, and that is the flare and relief system.

References:

SAES-F-007: Systems Design Criteria of Flares; Saudi Aramco

The National Fire Protection Agency Handbook of Fire Protection Engineering

American Petroleum Institute API-521

Perry's Chemical Engineers Handbook 6th edition

Occupational Safety & Health Administration

NOVA Safety and Environmental

Environmental risk assessment from a bioavailability perspective

➤ Salman Dossari, EPD

Think a dangerous substance in the soil or elsewhere in the environment can harm you? It can, but as it turns out, many health inspectors may need to consider many factors when protecting human health and gauging environmental risks in this

regard. Awareness now is growing among many experts that the total concentration of a toxicant in a contaminated environment may be leading inspectors and regulators to actually overestimate risks that pollutants may pose to humans,

animals and plants. While toxicity of a given pollutant is important, there's another factor that needs to be considered: the environmental risk regarding bioavailability.



(Photo Source: Saudi Aramco)

Background. Environmental risk is often defined as the “actual or potential threat of adverse effects on living organisms and the environment by effluents, emissions, wastes, resource depletion, etc., arising out of an organization’s activities.” Environmental exposures, whether physical, chemical, or biological, can induce a harmful response and may affect soil, water, air, natural resources or entire ecosystems [1]. The need for and the extent of remedial measures of contaminated sites are assessed based on the risk the contaminated sites pose to living organisms and the environment. Critical to risk assessment is a component known as bioavailability. Bioavailability refers to the extent to which humans and ecological receptors are exposed to contaminants in soil or sediment. In other words, bioavailability refers to the level a given substance must reach until it becomes available for intake by organisms (i.e., a chemical becomes bioavailable to humans when its presence becomes sizeable enough to attach itself to a sensitive receptor or organ). The concept of bioavailability has gained popularity among hazardous waste professionals as an important parameter in deciding clean-up levels. Because if contaminants in soil and sediments are not bioavailable, then more of the contaminant mass in question can be left in place without creating additional risks [2]. However, researchers have struggled in defining concepts such as bioavailability.

A bioavailable compound is defined as freely available to cross

an organism’s cellular membrane from the medium (e.g., soil) the organism inhabits at a given time. A bioaccessible compound is one that is available to cross an organism’s cellular membrane from the environment if the organism has access to the chemical. Bioaccessibility is more general than what is bioavailable; it encompasses what is actually bioavailable now plus what is potentially bioavailable. Distinguishing between bioavailability and bioaccessibility forces practitioners to consider what they actually measure with biological and chemical assays, which are supposedly developed to determine the ambiguously defined bioavailable fraction. Accordingly, routine chemical techniques described in literature, for example, actually estimate the bioaccessible rather than the bioavailable fraction. In truth, remediation scientists are probably more interested in what is bioaccessible over time at a given site than what is bioavailable [2].

Risk Assessment Using Current Analytical Methods

Current soil analytical methods used in risk assessment studies to quantify contaminants measure the total concentration of contaminants of concern and not bioavailable concentrations. Because of that, the magnitude of the environmental and societal risk from these pollutants may be overestimated. Moreover, recent research raises questions about the validity of current soil

analytical methods to assess the risk from organic pollutants. Fortunately, awareness is now growing among environmental toxicologists, risk assessors and regulatory agencies that the total concentration of a toxicant in a contaminated environment frequently overestimates the risk of pollutants to humans, animals, and plants [3].

Bioavailability and Toxicity

The total concentration of a contaminant in a polluted site is not directly related to its toxicity unless bioavailability of that contaminant is considered. Thus, the most contaminated sites are not necessarily the ones most toxic to soil-living organisms [4]. The bioavailable fraction is the critical parameter for uptake and ultimately for the concentration at the target sites in organisms, which is the critical parameter for toxicity [5]. For instance, drilling fluids typically contain heavy metals like barium, chromium, cadmium, mercury and lead. These metals can enter the system from materials added to the fluid or from naturally occurring minerals in formations being drilled. These metals, however, are not typically bioavailable [6]. The potential risk of metals in soils for man and the environment depends entirely on their bioavailability [7]. If the total concentration at a polluted site is greater than the regulatory level but the bioavailable concentration is below that value, a site that slated for expensive clean-up might, instead,

be deemed to present an acceptable risk [8].

Bioavailability and Time

Many studies have demonstrated that time has a significant impact on contaminant bioavailability. The decrease in bioavailability over the course of time is often referred to as aging or weathering. Many studies have concluded that bioavailability decreases as soil ages. Contaminants in field soils are often found to be less toxic than would be expected using laboratory tests with freshly spiked soils [9]. Studies on insecticides DDT and dieldrin have revealed that effectiveness in killing three species of insects was diminished as the chemicals aged in soil, yet 85% of the DDT and 92% of the dieldrin could still be recovered by vigorous organic solvent extraction methods [10]. Aging impacts on bioavailability may result from:

1. chemical oxidation reactions incorporating contaminants into natural organic matter,
2. slow diffusion into very small pores and absorption into organic matter, and
3. the formation of semi-rigid films around non-aqueous-phase liquids (NAPL) with a high resistance toward NAPL-water mass transfer [11].

The bioavailability to microorganisms decreases with time, though further declines become no longer detectable after arriving at a certain value. Although aging reduces exposure and thus toxicity and risk, it does not

eliminate exposure and risk. There will always be the unavailable fraction of the contaminant, which after some physical disturbance, may be released and become bioavailable. Although such compounds are aged in the sense of time, they have not been sequestered in a way to reduce their bioavailability to living organisms [12]. Nevertheless, a time-dependent decline in bioavailability does not always occur. This may be related to properties of the soil or of the contaminants.

Factors Influencing Bioavailability

Studies have shown that bioavailability of contaminants is influenced by many factors: physical characteristics of the soil (e.g., composition, particle shapes and internal porosities), chemical properties of the contaminants and soil and biological factors (e.g., microbial species and abundance, affinity for the contaminant, routes of exposure, and physiological attributes of organisms) [13]. Soil pH has been found to play a significant role in the contaminant behavior in soil such as solubility, speciation, precipitation, sorption/desorption and reaction behavior. For instance, a greater availability of heavy metal to soil biota was observed in acidic soil than in alkaline soil [14].

Another important factor influencing bioavailability is the presence of other chemicals. The presence of multiple contaminants results in increased competition for adsorption sites. As higher affinity adsorption regions become saturated by the competing

solutes, the sorption of any given contaminant will be increasingly limited to lower affinity partitioning domains [15]. This implies that one contaminant may outcompete another contaminant for adsorption sites rendering it more abundant in the aqueous phase.

Bioavailability Impact on Bioremediation

Bioremediation depends on the potential of microorganisms to uptake and metabolize contaminants, which are dependent on both accessibility and bioavailability. Once introduced into the soil, contaminants undergo a number of physico-chemical processes such as sorption and desorption, diffusion, and dissolution. The ability of soils to release (desorb) contaminants determines its susceptibility to microbial degradation, thereby influencing effectiveness of the bioremediation treatment [16]. A reduced bioavailability of contaminants in soil is caused by the slow mass transfer to the degrading microbes [17]. Accordingly, the biodegradation rate decreases as the contaminants' availability to microbes decreases.

Sorption, which influences the bioavailability of a contaminant, is a critical factor, yet a poorly understood process in bioremediation. There are two schools of thought concerning bioavailability and the consequent biodegradation of organic contaminants: (i) the pre-requisite release of contaminant from the sorbed phase to aqueous phase for its degradation by microorganisms, and (ii) biodegradation of the contaminant



(Photo Source: Saudi Aramco)

in the sorbed phase, without being desorbed, by the microbial enzymes [18]. On the other hand, some studies have shown that organic contaminants can also be degraded without prior desorption [19].

Bioremediation treatments act on the bioavailable fraction of the contaminant. The accessibility to the residual portion may be so low that the site presents little or no risk to higher organisms. Therefore, a site that was bioremediated but still contained concentrations of one or more contaminants above the target levels may have indeed been successfully cleaned up, even though conventional analysis suggested that the remediation was inadequate. This is true both of engineered and intrinsic bioremediation, which frequently do not destroy all of the targeted compounds [20].

Conclusion

Scientists are in consensus that bioavailability is critical to risk

assessment. However, the precise definition of bioavailability is controversial. It is now obvious that the total concentration of a toxicant in a contaminated environment frequently overestimates the risk of pollutants to recipients. The total concentration of a contaminant in a polluted site is not necessarily related to its toxicity unless bioavailability of that contaminant is considered. Many studies have concluded that as contaminated sites age bioavailability decreases as well. Bioavailability of contaminants is influenced by many physical, chemical, and biological factors. Bioremediation of contaminated sites is affected by the contaminants' availability to microbes. Research should continue in designing better analytical methods to measure the bioavailability of contaminants and linking those measurements to the potential toxicity and risk of a contaminant.

References

[1] <https://crawfordgts.com/services/>

[environmental-risk/environmental-risk-defined.aspx](#)

[2] Kirk. T. Semple, Kieron J. Doick, Kevin C. Jones, Peter Burauel, Andrew Craven and Hauke Harms. Defining Bioavailability and Bioaccessibility of Contaminated Soil and Sediment is Complicated. *Environ. Sci. Technol.*, 2004, 38 (12), pp 228A–231A

[3] Alexander, Martin (2000). Aging, Bioavailability, and Overestimation of Risk from Environmental Pollutants. *Environ. Sci. Technol.*, 2000, 34 (20), pp 4259-65

[4] Hallgren et al. *Chemosphere* 63 (2006) 1532–1538.

[5] Karl Fent (2004), Ecotoxicological effects at contaminated sites. *Toxicology* 205 (2004) 223–240

[6] John C. Reis (1996). *Environmental Control in Petroleum Engineering*, Gulf Publishing Company. Page 3.

[7] Cornelis A.M. van Gestel. Physico-chemical and biological parameters



(Photo Source: Saudi Aramco)

determine metal bioavailability in soils. *Science of the Environment* 406 (2008) 385-395.

[8] Alexander, Martin (2000). Aging, Bioavailability, and Overestimation of Risk from Environmental Pollutants. *Environ. Sci. Technol.*, 2000, 34 (20), pp 4259-65

[9] Same as above.

[10] Boakai K. Robertson and Martin Alexander. Sequestration of DDT and dieldrin in soil: Disappearance of acute toxicity but not the compounds. *Environmental Toxicology and Chemistry Volume 17, Issue 6, pages 1034–1038, June 1998.*

[1] Alexander, Martin (2000). Aging, Bioavailability, and Overestimation of Risk from Environmental Pollutants. *Environ. Sci. Technol.*, 2000, 34 (20), pp 4259-65

[12] Same as above.

[13] Nathan W. Haws; William P. Ball; Edward J. Bouwer. Modeling

and interpreting bioavailability of organic contaminant mixtures in subsurface environments. *Journal of Contaminant Hydrology* 82 (2006) 255–292.

[14] Hui Ming, WenXiang He, Dane T. Lamb, Mallavarapu Megharaj, Ravi Naidu, Bioavailability of lead in contaminated soil depends on the nature of bioreceptor. *Ecotoxicology and Environmental Safety* 78 (2012) 344–350.

[15] Nathan W. Haws; William P. Ball; Edward J. Bouwer. Modeling and interpreting bioavailability of organic contaminant mixtures in subsurface environments. *Journal of Contaminant Hydrology* 82 (2006) 255–292.

[16] Ramakrishnan B, Megharaj M, Venkateswarlu K, Sethunathan N, Naidu R. Mixtures of Environmental Pollutants: Effects on Microorganisms and Their Activities in Soils. *Reviews of Environmental Contamination and Toxicology*, 2011; 211: 63-120.

[17] R. Boopathy. Factors limiting bioremediation technologies. *Bioresource Technology* 74 (2000) 63-67.

[18] Ramakrishnan B, Megharaj M, Venkateswarlu K, Sethunathan N, Naidu R. Mixtures of Environmental Pollutants: Effects on Microorganisms and Their Activities in Soils Reviews of Environmental Contamination and Toxicology, 2011; 211: 63-120.

[19] Singh N, Megharaj M, Gates WP, Churchman GJ, Anderson JA, Kookana RS, et al. Bioavailability of an organophosphorus pesticide, fenamiphos, sorbed on an organo-clay. *J Agric Food Chem* 2003;51:2653–8.

[20] Alexander, Martin. Aging, Bioavailability, and Overestimation of Risk from Environmental Pollutants. *Environ. Sci. Technol.*, 2000, 34 (20), pp 4259-65.

In Focus



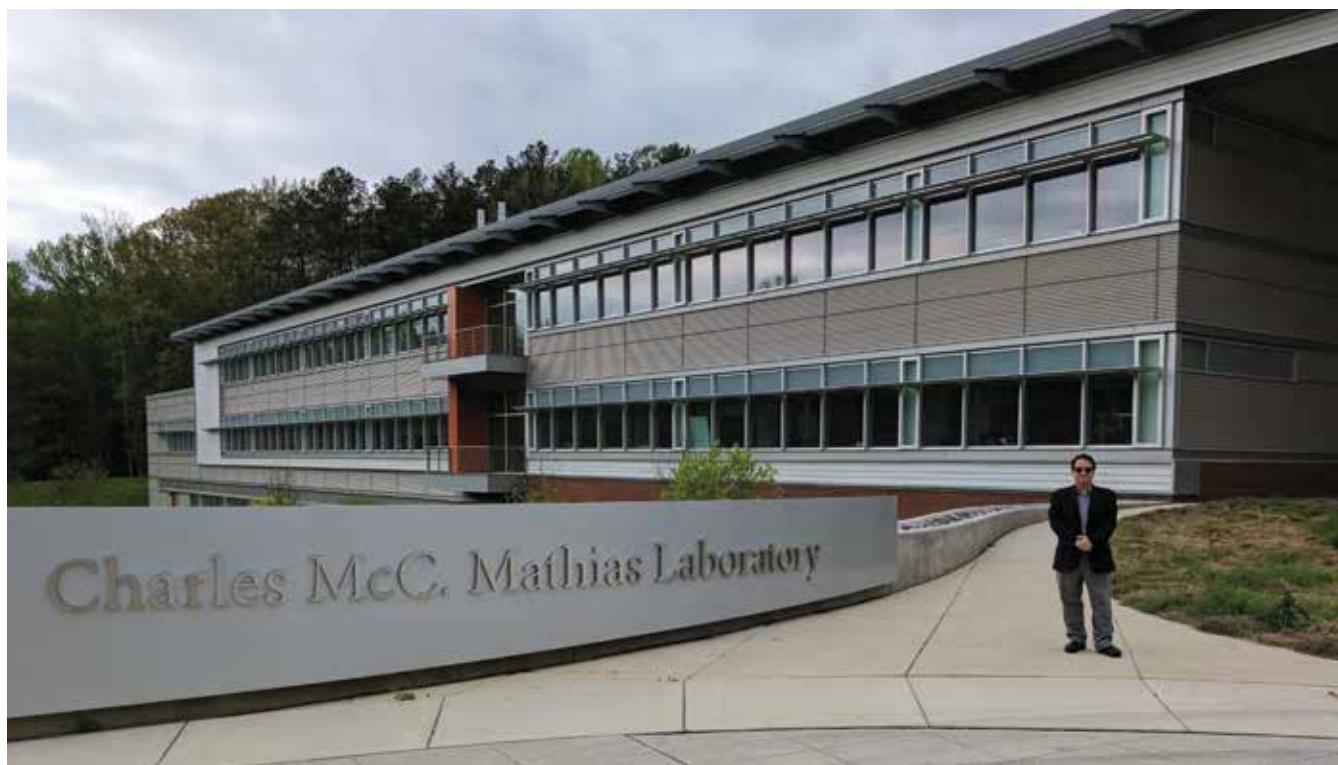
Photo Source: Saudi Aramco

Smithsonian's “Movement of Life” comes to Saudi Arabia

EPD worked with Saudi Aramco's Washington office to redirect the "Movement of Life" project to Saudi Arabia for the next three years. Funded by Saudi Aramco donations, the project is currently conducted by the Smithsonian Institution (SI) in Washington, D.C. Video-conferencing meetings between SI and EPD scientists will determine the

technical requirements and logistical needs for this move that is slated to begin in mid-2018. During this visit EPD delivered presentations at the Smithsonian's Conservation Ecology Center and the Environmental Research Center highlighting Saudi Aramco's major environmental and biodiversity initiatives. Additional presentations were also delivered

to the Saudi Aramco office in Washington and via teleconferencing to the Houston office. Attendees have praised the company for its long-lasting and diverse environmental initiatives and efforts that illustrate a strong commitment toward environmental protection and conservation.



EPD's Khaled Abdulkader at the Smithsonian's Charles McC. Mathias Laboratory in Edgewater, Md.
(Photo Source: Saudi Aramco)

ES/EPD SMEs Chair the 95th PERF Spring Meeting in The Hague, Netherlands

In support of knowledge sharing and to promote national interest, the Environmental Protection Department (EPD) chaired the 95th Spring Meeting of The Petroleum Environmental Research Forum (PERF), which took place in The Hague, Netherlands, on April 24-26, 2017. Aramco Overseas Company sponsored the event, which focused on three themes: Global Methane Opportunities in the Oil & Gas Industry, Low Emissions Roadmaps and Carbon Capture. To support global methane opportunities in the oil and gas industry, EPD delivered a technical presentation titled

"Saudi Aramco Flaring Minimization Program," which recounted success stories of its Flaring Minimization Program (FMP). With respect to demonstrating Saudi Aramco's carbon capture projects, a technical presentation titled "Blue Carbon in Saudi Arabia" highlighted the company's achievements sequestering CO₂ via marine flora, specifically mangrove forests along the Arabian Gulf coast. Overall, the PERF event covered subjects of interest to EPD, and the delivered presentations were well received and highly appreciated by the audience.

Seventy Attend EPD's 26th Environmental Stewardship Workshop

Roughly 70 participants from various Saudi Aramco departments

explored a variety of topics on conserving natural resources and ensuring workplace health at EPD's 26th Environmental Stewardship Workshop on April 12-13, 2017. The event, which took place at the R&DC Technical Exchange Center, forms part of broader efforts to expand awareness over a growing number of environmental issues facing the company. Workshop topics covered essential elements of environmental protection programs and provided attendees with the knowledge necessary to fulfill their organizations' responsibilities in support of Saudi Aramco's Environmental Protection Policy. Environmental awareness is crucial for the company's rapidly changing workforce, for younger leaders especially. To date, over 920 of the company's chief position holders have participated in Environmental



EPD's Yasser Kattan speaks at the 95th Spring Meeting of The Petroleum Environmental Research Forum in The Hague.
(Photo Credit: Saudi Aramco)

Stewardship Workshops, which take place twice a year.

EPD Hosts 2017's First Environmental Coordinators Workshop

More than 150 attended EPD's first Environmental Coordinators (ECs) Workshop for 2017 on April 20 at the R&DC Technical Exchange Center. These biannual workshops form part of the department's ongoing efforts to enhance environmental capacity-building and promote knowledge sharing and transfer across the company. The venue also provides attendees with the opportunity to share their experiences, exchange information on new technologies and find solutions to concerns and challenges through discussions with peers. ECs deliver presentations on their organizations' environmental achievements and best practices that have improved overall facility environmental performance, while EPD SMEs deliver presentations to update ECs with new studies, technologies and standards. All in attendance addressed a wide variety of topics on conserving natural resources, biodiversity, environmental health and environmental engineering.

EPD Representative Obtains UNFCCC Expert Greenhouse Gas Review Certification

An EPD representative successfully obtained professional certification as an "Expert Reviewer for the Technical Review of Greenhouse Gas



A Saudi mangrove forest, which can absorb noteworthy amounts of CO₂ in a process known as Blue Carbon, the topic of an EPD-KAUST workshop.
(Photo Source: Saudi Aramco)

Inventories of Parties Included in Annex I to the Convention" offered by the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC). The certification took place at Victoria Falls, Zimbabwe, on March 21-23, 2017. EPD acts as the focal point for the company's greenhouse gas (GHG) inventory reporting submissions to the Designated National Authority (DNA), which requires advanced technical knowledge of GHG inventory reports. This certification enables the department to develop and process technical reviews of Saudi Aramco GHG inventory reports, while adhering to UNFCCC modalities, procedures and guidelines. The certification will also give EPD the tools to provide technical assistance — to the Ministry of Energy, Industry and Mineral Resources — in multilateral inventory review processes, and also ensure that recommendations for future reporting enhancements address the company

and energy sector in a balanced manner.

EPD, KAUST Delve Deep into Blue Carbon at Workshop

EPD representatives participated in a Blue Carbon Workshop organized and hosted by KAUST. This workshop, which saw attendance by the Deputy Ministry of Environment, Water and Agriculture, covered many areas related to Blue Carbon challenges and opportunities in the region. Blue Carbon offsets carbon emissions via sequestration by coastal and marine habitats, mangroves especially. During this workshop, EPD representatives led a technical session and delivered a presentation on "Mangrove Restoration Techniques in the Region (Arabian Gulf and Red Sea)." This workshop forms part of ongoing studies conducted by EPD and KAUST on current carbon sequestration within Saudi Aramco concession areas along the Arabian Gulf.

EPD Hosts KFUPM Chemical Engineering Chem-E-Car (Sadeem) Team

EPD hosted the SADEEM Chem-E-Car team from King Fahd University of Petroleum and Metals (KFUPM) to present details of its innovative green prototype car and demonstrate its features. The car's development was motivated by a global contest organized by the American Institute of Chemical Engineers, which engages college students in creative green technology designs. The team has participated in three competitions, and has won one international and three regional awards so far. Building on their experience as they progress, the students have designed three models of the car, which runs on hydrogen produced from a reaction within the car's structure.

The presentation aims to highlight the team's efforts, and explore potential areas for collaboration, to further encourage their impressive representation of the Kingdom at international competitions.

Saudi Aramco Participates in Multilateral Climate Change Venue

EPD supported the Ministry of Energy, Industry and Mineral Resources in climate-change negotiations at an Informal Meeting on Further Actions against Climate Change, co-chaired by Brazil and Japan. This meeting served as an opportunity for the Kingdom to engage with chief negotiators from 20 selected countries influential in climate-change negotiations. The encounter saw attendance on the part of the United

Nations Framework Convention on Climate Change (UNFCCC) Secretariat to decide on areas of focus for formal negotiations throughout the year. The meeting included an assessment of the results from COP 22 in Marrakech, Morocco, in November 2016, and also looked ahead to negotiations leading to COP23 to be held in Bonn, Germany, in November 2017. Agenda items focused on Monitoring, Review, and Verification of Green House Gases and Carbon Market issues.

EPD Enhances Weather and Sea State Forecasting System (WASSF)

EPD earlier in 2017 announced the release of a newly enhanced version of its Weather and Sea State Forecast (WASSF) system to all Saudi Aramco



The Chem-E-Car (Photo Source: KFUPM)

Employees. The WASSF (www.wassf.net) provides high-resolution, hourly weather, and sea-state forecasts, to support Saudi Aramco's onshore and offshore operational areas, as well as enhance safety. The system provides weather forecast briefs for everyday use such as work, travel, outdoor recreation activities, sports and marine activities, among others. The new system's enhancements extend the forecast period from five (5) to seven (7) days, and have revamped the

home page to allow for a more user-friendly experience for the broader Saudi Aramco community.

EPD Hosts Desert Research Specialists from Tottori University, Japan

EPD hosted a four-day visit for members of the Arid Land Research Center (ALRC), Tottori University, Japan. The visit was facilitated by

Aramco Asia Japan as part of an Aramco donation to the ALRC. EPD took ALRC on site visits to company desert restoration activities in Dhahran and Shaybah, and to traditional agriculture sites in the Asir Mountains. Further, EPD and ALRC discussed potential applied research collaboration that might be of direct benefit to Saudi Aramco's attempts to mitigate sand movement and enhance biodiversity.



EPD's Christopher Boland, left, and Abduallah Alsuhaiibany, right, meet with representatives from Tottori University's Arid Land Research Center in Dhahran to discuss Saudi Aramco's desert restoration activities. (Photo Credit: Saudi Aramco)



Enviro Snaps

Rock Star: The Anderson's Rock Agama, a colorful citizen of the Arabian highlands

The Anderson's Rock Agama (*Acanthocercus adramitanus*) is a terrestrial lizard endemic to the Arabian Peninsula. It's widespread in elevated mountains, found 2,000 meters above sea level. Males are colorful, with a blue body and an orange tail, while the females are brown with vertical stripes. These cold-blooded reptiles need sun to warm their bodies. Males can usually be seen on vertical boulders raising their heads up and down to warn other males from coming close to their territory. Keep an eye out for this colorful denizen of the region's fascinating terrestrial ecosystems.



Schedule of Events

Date	International Events*	Location
Sept. 4-8, 2017	4th International Marine Protected Areas Congress (IMPAC4)	La Serena, Chile
Sept. 4-15, 2017	13th Session of the Conference of the Parties (COP 13) to the UN Convention to Combat Desertification (UNCCD)	Ordos, Inner Mongolia, China
Sept. 6-10, 2017 (tentative)	46th Session of the Intergovernmental Panel on Climate Change (IPCC)	TBA
Sept. 12-25, 2017	72nd Session of the UN General Assembly	New York
Sept. 25-29, 2017	1st Meeting of the Conference of the Parties to the Minamata Convention on Mercury	Geneva
Sept. 27, 2017	World Tourism Day 2017: Sustainable Tourism—A Tool for Development	Doha
Oct. 15-18, 2017	SPE Kuwait Oil & Gas Show and Conference	Kuwait City
Oct. 23-25, 2017	Global Science, Technology and Innovation Conference (G-STIC) 2017	Brussels
Oct. 23-27	4th Intergovernmental Review Meeting on the Implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities	Bali
Oct. 30-Nov. 17, 2017	International Civil Aviation Organization (ICAO) Council 212th Session	Montreal
Nov. 6-17, 2017	UNFCCC COP23	Bonn
Nov. 13-16, 2017	SPE—The Abu Dhabi International Petroleum Exhibition & Conference (ADIPEC)	Abu Dhabi
Dec. 4-6, 2017	3rd Meeting of the UN Environment Assembly (UNEA 3)	Nairobi
Dec. 13, 2017	European Coral Reef Initiative	Oxford, U.K.
Date	National Events	Location
Oct. 10-11, 2017	SAEEP Closing Ceremony	Taif
Oct. 17-19, 2017	Water Arabia	Khobar
Date	Saudi Aramco Forecasted Facilities Environmental Events/Topics	Location
Aug. 28, 2017	Wastewater Management Presentation	Shaybah Producing Dept.
Oct. 1, 2017	GHG Emissions and Climate Change Workshop	Aviation Dept./KFIA
Oct. 12, 2017	Environmental Awareness Session	Jeddah Refinery
Oct. 25-26, 2017	Waste Minimization Best Practices	WGPD & KGPD
November, 2017 (Date TBD)	Beach Cleanup Campaign	Ras Tanura
November, 2017 (Date TBD)	Schoolchildren Environmental Awareness Day	Dhahran
December, 2017 (Date TBD)	Beach Cleanup Campaign	Qurayyah Beach

Date	Annual International Environmental Days* *
March 22	World Water Day
April 22	World Earth Day
May 22	World Biodiversity Day
June 5	World Environmental Day
Sep 16	Preservation of the Ozone Layer
Sep 28	World Maritime Day

* Source: International Institute for Sustainable Development, UN, Society of Petroleum Engineers

** Source: UN/Environmental Technology & Management Association

EPD does not guarantee the accuracy of this calendar, as dates and events are subject to change, postponement or cancellation.

enviro news

Environmental Protection Department Newsletter

Second Quarter 2017 Issue No. | 26