

# enviro news

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Environmental Protection Department Newsletter

Second Quarter **2016** Issue No. **24**



Sand dunes roll in the Rub' al Khali desert  
(Photo Credit: Chris Boland, EPD)



# A Message from the EPD Manager

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Dear Readers,

The Environmental Protection Department is pleased to present Issue #24 of Enviro News. The magazine's Editorial Board continuously strives to enhance content and publish news on developments unfolding not only within Saudi Aramco's various departments, but outside areas of operation as well. In this issue, Enviro News will highlight Saudi Aramco's support for the Kingdom at the COP21 climate-change summit in Paris, whose ramifications will affect the oil and gas industry, Saudi Aramco and the entire world. As our CEO, Amin H. Nasser, observed at the President's Award for Environmental Excellence ceremony in May, global acceptability — as a company and as an industry — will be increasingly dependent on environmental performance, especially as Saudi Aramco plays a key role in the Kingdom's economic transformation. Enviro News aims to report on areas of progress. This edition includes Saudi Aramco's role in global climate-change venues at home and abroad, news on initiatives that various departments are undertaking to conserve natural resources as well as items on new technologies and best practices to produce energy in an environmentally friendly manner.

Today, all of the company's efforts that minimize its environmental footprint are paying off. The volume of flared gas held well below 1% of total raw gas production for a fourth consecutive year in 2015. The volume of hydrocarbon discharges from coastal facilities fell to its lowest level on record — down 95% from 2007 baseline levels, while SO<sub>2</sub> emissions remain low despite increased processing of sour hydrocarbons.

In the area of water conservation Saudi Aramco continues to maximize wastewater reuse while promoting sustainable alternatives to groundwater. Today, Saudi Aramco reuses more than 75% of its sanitary wastewater, which is among the highest in the region.

Among achievements in environmental awareness, the Saudi Aramco Environmental Education Program has reached 1,630 schools. The program, which promotes awareness among our most valuable resource — our children — has grown to include 1,146 Friends of the Environment groups.

Enviro News serves as a platform for all departments to convey to the company, the community, the Kingdom, and the world, all Saudi Aramco does to reduce emissions, safeguard air, water and land resources and ensure worker and community health. The Editorial Board encourages all operating and support services departments to submit environmental success stories for publication going forward.

**Osama I. Fageeha**

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# Horizons

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# Saudi Arabia makes its presence known at U.N., Berlin climate-change meetings

By Abdullah Tawlah, EPD

His Excellency Khalid A. Al-Falih, the Kingdom's Minister of Energy, Industry and Mineral Resources, met with high-level United Nations officials in NYC to discuss collaboration between Saudi Arabia and the U.N. regarding climate change issues. Saudi Arabia has played pivotal roles in multilateral climate-change and other environmental venues this year, especially in the wake of the COP21 climate change summit in Paris in December of 2015.

Al-Falih also participated in the VII Petersberg Climate Dialogue in Berlin, where he attended high-level discussions on climate change alongside the world's leading climate and energy experts and foreign energy ministers. The event took place under the patronage of German Chancellor Angela Merkel and was hosted by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. The two-day event was considered to be a stepping stone to set up the agenda and expected deliverables for the upcoming COP22 climate change summit in Marrakesh, Morocco. The gathering included panel discussions on greenhouse gas and resilient development, post-COP21 climate initiatives, and roundtable discussion on long-term visions. The Kingdom highlighted its economic transformation and diversification plans, and how they will help meet climate and development goals underscored by the COP21 Paris agreement.



His Excellency Khalid A. Al-Falih participates in the VII Petersberg Climate Dialogue in Berlin. (Source: Saudi Aramco)



His Excellency Khalid A. Al-Falih, the Kingdom's Minister of Energy, Industry and Mineral Resources, attends a United Nations meeting to discuss collaboration on climate change issues. (Source: Saudi Aramco)

# Work ahead. World celebrates COP21, but work remains for Saudi Aramco

By Raed Basseet, EPD



His Excellency then Minister of Petroleum and Mineral Resources, Ali Al Naimi, speaks with U.N. Secretary General Ban Ki-moon at the COP21 climate-change summit in Paris. (Photo Source: KSA-COP21.com)

COP21 has come and gone, and the whole world is claiming success, and it should. It's no easy task to assemble close to 200 nations to hammer out a global climate-change accord. Saudi Arabia's environmental protection efforts have included serious investments in the development of technologies and best practices that reduce our environmental footprint and greenhouse gas emissions. Saudi Arabia, like other nations including the like-minded developing countries,

managed to ensure that provisions in the final agreement will assign sustainable development plans as an overriding priority. These plans will keep emissions in check as will serious contributions to cut greenhouse gas emissions. Securing this historic agreement doesn't mark the end of the journey, it marks the beginning of a tough climb balancing sustainable development goals with mitigation and adaption efforts to protect the environment, as

governments will engage in drafting specific game plans to comply with the general framework. Future COP meetings and other working groups are planned for this year and beyond, as now the tough tasks of implementing the agreement and Intended Nationally Determined Contributions (INDC) lie ahead. The Kingdom's INDCs were submitted to United Nations Framework Convention on Climate Change by the Designated National Authority for Clean

## Development Mechanisms—DNA.

The INDC approach implements actions that the Kingdom will advance as part of its economic diversification plans and adaptation efforts to achieve mitigation co-benefits ambitions of up to 130 million tons of CO<sub>2</sub> equivalent avoided by 2030 annually. Different national stakeholders contribute to the implementation of these actions and plans, including Saudi Aramco.

For example, Saudi Aramco's Water Conservation Strategy will drastically reduce freshwater consumption by maximizing wastewater reuse, optimizing water usage, promoting the use of sustainable alternatives and controlling water losses.

The company already reuses more than 75% of its sanitary wastewater.

Those operations that do require water for industrial reasons rely increasingly more on renewable seawater, which keeps precious groundwater under the surface of the earth. Elsewhere, Saudi Aramco is optimizing all of the practices and technologies used in the discovery, recovery, processing, distribution and

end-use of energy resources to ensure energy efficiency and reduce local pollutants and global greenhouse gas emissions.

Saudi Aramco is an industry leader in cutting flaring, with total flared gas consistently hovering below 1% of total raw gas throughput each year.

Other climate-change adaptation projects will progress as well, including the development of the company's vehicular onboard carbon capture storage system.

The company's cross-sectional scale model of a CO<sub>2</sub>-enhanced oil recovery, a technique used at Uthmaniyah, will help the Kingdom balance sustainable development with mitigation co-benefits, while renewable energy contributes to company plans as well.

The Paris agreement to reduce emissions may change the global energy arena. But equally as important, the responsible use of fossil fuels remains crucial for global economic health and lifting countless lives out of poverty, and Saudi Aramco will continue to supply global demand in a responsible fashion.

Countries will need fossil fuels to industrialize in sustainable manners, and nations will need fossil fuels to commute and to heat and cool their homes.

Fossil fuels will continue to bolster the global refining and petrochemical industries as well. New industries such as petrochemicals will not only drive growth, they'll create value-added jobs in the future for the company as well, especially when new technologies play a role.

"Technology provides the answer to climate change challenges. It has done so for mankind throughout history, and it requires Greater Innovation, Collaboration, and Investment," His Excellency then Minister of Petroleum and Mineral Resources, Ali Al Naimi, said recently. Saudi Aramco will be there producing oil, gas and a broad array of derivatives to meet global demand while safeguarding our planet at the same time.

*Editor's Note: A version of this story previously ran in The Arabian Sun.*



Christiana Figueres, UNFCCC Executive Secretary, and Amin H. Nasser, President & CEO, Saudi Aramco, present the company's "Marine Atlas of the Western Arabian Gulf" at the COP21 global climate-change summit in Paris (Photo source: Saudi Aramco).

# Winners. Five departments take home president's award for environmental excellence

By Forrest Jones, EPD



East-West Pipelines Department (Category: Most Improved Organization)



Abqaiq Plants Operations Department (Category: Operating Organizations)

Five departments won the 2015 President's Award for Environmental Excellence on May 11, in a ceremony that underscored Saudi Aramco's increasing adeptness at protecting the Kingdom's natural resources. The award goes to departments that display excellence in four categories:

compliance, performance, awareness and training, and initiatives. Areas considered include four environmental arenas — land, water, marine and air — and three health arenas — environmental health, industrial hygiene and radiation protection. When choosing winners,

the Environmental Protection Department (EPD) gathers thousands of data points across more than 20 parameters, all of which are evaluated to estimate the environmental performance index for both operating and support-services organizations.

**For the 2015, the winners were:**

**Operating Organizations:**

- Yanbu' Refinery Department
- Hawiyah NGL Recovery Plant Department
- Abqaiq Plants Operations Department

**Support Services Organizations:**

- Aviation Department

**Most Improved Organization:**

- East-West Pipelines Department

The scoring methodology accommodates the broad diversity of Saudi Aramco's operations and provides a reliable and repeatable method of ranking facilities. Proponent organizations are hard at work to win, and even if they don't take home the trophy, the Kingdom's environment wins more and more as time goes on. Over the last 10 years, for example, the EPD has reviewed and scored more than 5,000 initiatives submitted by proponents, while environmental coordinators have logged tens of thousands of training hours. Add to that, nearly 2,000 environmental awareness events and



campaigns have taken place, and finally, EPD has collected and analyzed tens of thousands of individual data points across all environmental disciplines.

“Although we are only recognizing five organizations today, I would like to emphasize that all operating and supporting organizations have exerted significant efforts to protect the environment” EPD Manager Osama I. Fageeha said at the event.

Before a packed house of more than 180 people, Saudi Aramco President & CEO Amin H. Nasser in his keynote speech highlighted the facts and figures that illustrate the company’s commitment to reducing its environmental footprint.

The volume of flared gas, for example, remained below 1% of total raw gas production for a fourth consecutive year in 2015. The volume of hydrocarbon discharges from coastal facilities reached its lowest level on record, a 95% reduction from 2007 baseline levels, while SO<sub>2</sub> emissions remain low despite increased processing of sour hydrocarbons.

Water reuse at Saudi Aramco, meanwhile, is among the highest in the region, while groundwater consumption supplies only 20% of the company’s needs. Furthermore, wastewater compliance reached new highs in 2015, with environmental findings at their lowest level on record.

Elsewhere, Saudi Aramco employees provided policy support for the Kingdom in the COP21 Paris climate change summit and in other multilateral venues.

“Our global acceptability – as a company and as an industry – will be increasingly dependent on our environmental performance,” Nasser said. “And it will play a major role

in our acceptability here at home, as we assume an even more pivotal role in the Kingdom’s economic transformation. We must therefore manage our environmental footprint (and specifically our carbon emissions) even more effectively – wherever we

operate—as we take on new tasks.” This year’s ceremony was the 11th for Saudi Aramco.

Today, over 40 departments compete to take home the prize.



Hawiyah NGL Recovery Department (Category: Operating Organizations)



Yanbu’ Refinery Department (Category: Operating Organizations)



Aviation Department (Category: Support Services Organizations)

Editor’s Note: Photo source: Saudi Aramco

# Center stage: Saudi Aramco grabs spotlight at PetroEnvironment

By Umar Zahrani, EPD



Industry leaders learn from each other and from PetroEnvironment's many different exhibits. (Photo Source: Saudi Aramco)

Saudi Arabia is making its presence increasingly known on global stages. At the COP21 climate change summit in Paris late last year, company employees supported the Kingdom in negotiating capacities behind the scenes, while other subject matter experts unveiled our environmental technology and best practices on the sidelines to a broad audience worldwide.

Our work here is not over yet, as the near 200 countries that signed the Paris agreement now must turn their plans to lower emissions and protect the

environment into reality.

That takes work, and it will also take effective communications to convince the world that the Kingdom is doing what it says it will.

To succeed, Saudi Aramco will continue to communicate to the world that it can support the Kingdom in its tasks to reduce its environmental footprint. Earlier in 2016, many company representatives participated in a high-profile event to do just that — PetroEnvironment, the 8th Symposium and Exhibition on Environmental

Progress in the Petroleum and Petrochemical Industry. Held under the patronage of H.R.H. Prince Saud bin Naif bin Abdulaziz Al-Saud, Governor of the Eastern Province, PetroEnvironment 2016 kicked off in February with a warm welcome delivered by EPD Manager and PetroEnvironment Chairman Osama Fageeha, followed by an address by Abdullah Q. Al-Baiz, Executive Director of Engineering Services.

For 2016, the symposium carried the theme "Partnering for Environmental

Sustainability,” which highlighted the importance of environmental and sustainability issues in both Upstream and Downstream sectors. PetroEnvironment 2016 offered five interactive pre-symposium workshops, attended by more than 110 delegates from Saudi Aramco, other industries, and government agencies.

The event included more than 60 technical presentations, and delivery of 40 papers that discussed various environmental areas of significance to the region, and the petroleum and petrochemical industries. Topics included climate change and the implications of the COP 21 Paris agreement on the industry and the region, water conservation and wastewater management, air pollution monitoring and control, biodiversity conservation, marine protection, economic valuation of natural ecosystems, meteorological modeling, and occupational and environmental

health, among others. Saudi Aramco representatives were plentiful both in attendance and on-stage, as roughly 30 presentations were delivered by company subject matter experts. The associated exhibition consisted of 40 companies focusing on innovative solutions, technological advancements, sharing best practices and fostering partnerships among various stakeholders to address environmental challenges and support sustainability objectives. PetroEnvironment is one of many symposiums that have showcased Saudi Aramco efforts to supply energy to the world, in an environmentally sustainable manner. The Kingdom has placed technology leadership at the heart of its efforts in addressing climate change challenges, and fostering environmental stewardship. Saudi Aramco is helping to spearhead these efforts and has invested heavily in its research and development endeavors since the

establishment of its Accelerated Transformation Program (ATP). The company’s R&D network now has global reach with the opening of research centers and technology offices in North America, Europe, and Asia — 11 in all.

Our global research drive covers a very broad spectrum of the energy value chain, from exploration, refining, and power generation, to value adding products and solutions, delivered to end-users around the world. Aramco’s R&D Center in Dhahran helps to drive both operational excellence and improve environmental performance. This dual approach is prominent in the field of carbon management. Rather than limiting the focus to reducing the operational environmental footprint, the company is also looking at how it can help provide solutions to some of the world’s most pressing challenges regarding greenhouse gas (GHG) emissions.



EPD Manager Osama I. Fageeha speaks at PetroEnvironment 2016. (Photo credit: Saudi Aramco)

# New initiatives in 2015 highlight company drive for environmental excellence

By Yanbu Refinery, Riyadh Refinery, JNGLFD and Khurais Producing Staff



The desert encroaches a highway near Khurais Producing Department (left), though trees planted along the road (right)—which have been treated with a superabsorbent polymer to use less water—will control the drifting sands. (Photo Source: Khurais Producing Department, Saudi Aramco)

A slew of initiatives rolling out across the company designed to reduce Saudi Aramco's environmental footprint are drawing applause these days, including those submitted to the President's Award for Environmental Excellence. Each year, departments submit their initiatives to compete to win this esteemed prize. Winning the award is a big deal, but concrete plans to reduce the company's environmental footprint, and protecting worker and community health, are even more important.

While there are too many initiatives to be covered in this issue of Enviro News, the following represent a good cross section. Stay tuned for future editions of Enviro News for more coverage of Saudi Aramco initiatives to protect our environment.

## **Khurais Producing: Groundwater Conservation Achievements**

*By Ahmed Alrasheed and Mustafa Jubran, Khurais Producing Department*

Also highlighted this year is Khurais Producing Department's (KhPD) use of a new polymer to improve water usage. In 2015, KhPD conducted two groundwater conservation studies for the consumption rate of the groundwater for irrigation and crude washing purposes. In this regard, KhPD in collaboration with EPD underwent a trial test to study the performance of a new superabsorbent polymer in reducing required irrigation water when mixed into the soil. The polymer can absorb 500 times its weight in water, which increases the soil's water retention and thus reduces watering frequency. It was tested on a new plantation project to control

sand drifting onto Khurais roads. The plantation phase completed in March of 2015 with a total of 3,400 trees planted along 2.6 km of Khurais's main access road. By the end of January 2016, KhPD had successfully conserved around 11.4 million liters (MML) of groundwater. This happened as a consequence of relaxing the irrigation frequency to once every five days as opposed to every two days under normal municipality irrigation.

## **Riyadh Refinery: Eliminating Oil Water Discharge from Crude Tanks with Automated Hydrocarbon Tank Dewatering System**

*By Abdulmalik A. Al-Turki, Riyadh Refinery Department*

Riyadh Refinery has launched an initiative to eliminate oily water discharge from crude tanks through an

advanced hydrocarbon tank dewatering system. The department has installed a new, state-of-the-art control unit in the dewatering system to ensure that water and only water is discharged into the oily water sewer. This system, developed and patented by Saudi Aramco Riyadh Refinery engineers Fawaz A. Al-Sahan and Omar Z. Al-Zayed, utilizes sound velocity technology capable of recognizing the difference in density of hydrocarbon liquid and water as it passes through the pipe. The new technology to eliminate hydrocarbon discharge into the oily water sewer has enabled Riyadh Refinery Department to achieve 97% of its industrial wastewater compliance KPI. Moreover, as it is fully automated, the new system has eliminated the risks associated with hydrocarbon discharge into the oily water sewer, the risks of potential hydrocarbon fume inhalation in the old manual system and the associated risks of hydrocarbon spills. It is worth mentioning that Riyadh Refinery's in-house invention, when compared to other conventional types, is cheaper in cost by 70%.

### **Ju'aymah NGL Fractionation Department: Spent Caustic Disposal Volume Reduction**

*By Eid F. Al-Helal, JNGLFD*

Ju'aymah NGL Fractionation Department (JNGLFD) has unveiled ways of better handling caustic. JNGLFD generates spent caustic as part of its process for removing mercaptan from final products in the MEROX System. Generated spent caustic cannot currently be recycled, reused or disposed in the Kingdom. It is disposed internationally at great expense, which also carries risks to the environment. Better system handling and improved processes have given the department tools to increase caustic concentration and strength, which allows for longer use and cuts down on disposal. The initiative translates into savings of \$481,000 a year in reduced shipment costs, while potential health hazards associated with transporting caustic fall as well. In 2013, JNGLFD had 380,000 gallons of spent caustic, a figure that could drop by 80% this year.

### **Yanbu' Refinery: Reusing 11.5 Million Gallons of Stripped Water Annually**

*By Gopinath Tholasingam, Waleed F. Alkhateeb, Yanbu Refinery*

Elsewhere, as a part of its water conservation efforts, Yanbu' Refinery Department has implemented the design modifications to route the stripped sour water from the sour water stripper unit to the CDU desalting water drum. Accordingly, new piping was installed in addition to the reconfiguration of tower level control loops and the emergency shutdown system (ESD). This initiative enabled the department to reuse 11.5 million gallons of stripped water annually, and eliminated the waste water return to the Royal Commission by the same amount. The initiative, which cost \$150,000, will generate significant annual water savings.

Not all departments can win the President's Award for Environmental Excellence, but with competition increasing each year, the company's environmental footprint shrinks ever further, while worker and community health and safety standards continue improving.



# Oxy combustion: a hot new way to produce power and curb emissions

By Maddala Bhanumurthy, Yanbu' Refinery

Saudi Arabia is working hard to diversify its energy mix so it can meet both internal and external demand. It's no secret demand for energy in the Kingdom is growing, while Arabian crudes are facing increasing competition abroad from other fossil fuels and renewable energy sources. While demand for crude oil isn't going away anytime in the near, medium or long term, the time for sustainable use of the commodity is becoming the norm here and everywhere else. Natural gas and renewable energy will play a part in the Kingdom's business plans, but on the flip side of the search are cost-effective energy solutions including cost-cutting measures. One such technology is making a difference when it comes to using fossil fuels to produce electricity. Carbon capture and sequester has a new tool in its quiver to allow for cleaner and more efficient production of energy. Meet oxy-fuel combustion, an alternative to current fossil-fuel power generation practices.

## Oxy Fuel: Saving Money, Saving the Environment

Under this application, fossil fuels used to produce electricity are combusted using pure oxygen instead of ordinary air, which contains roughly 78% nitrogen by volume. Using pure oxygen

cuts nitrogen from passing through the process and carrying away heat, which reduces the volume of fuel gas burned and carbon dioxide normally headed up the smokestack and out into the atmosphere. This smaller but more concentrated pocket of CO<sub>2</sub> is then captured and stored more easily and cheaply, which protects the environment by curbing more greenhouse gas emissions. Stored CO<sub>2</sub> can later be sold, which adds even more value.

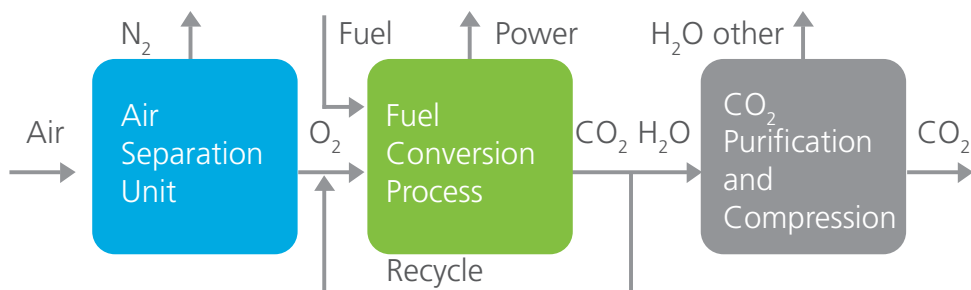
Research is currently underway to determine how to most efficiently run fossilfuel power plants across the globe with an oxygen-enriched gas mix instead of air. Almost all of the nitrogen is removed from input air, yielding a stream that is approximately 95% oxygen. But producing electricity with pure oxygen will increase flame temperatures significantly, so the mixture is diluted with recycled flue gas to moderate the temperature to conventional boiler specifications. The recycled flue gas can also be used to carry fuel into the boiler and ensure adequate convective heat transfer to all boiler areas. In the end, oxy-fuel combustion produces approximately 75% less flue gas than air-fueled combustion and produces exhaust consisting primarily of CO<sub>2</sub> and H<sub>2</sub>O (see list of advantages below). Yanbu' Refinery Department is currently working with R&DC to pilot a project utilizing such technology. Saudi Aramco's oxyfuel project was recognized by the Carbon Sequestration Leadership Forum for contributing advancing efficient carbon capture technologies. If established, the pilot project will be the first of its kind ever established in Middle East. Such a move would benefit Saudi Arabia in its efforts to reduce the Kingdom's energy intensity (less energy consumption per generation of a unit of power). Moreover, the technology will reduce cutter stocks like kerosene and diesel used for cutting fuel oil viscosity for easy transportation.

**Advantages:** The justification for using oxy-fuel is to produce a CO<sub>2</sub>-rich flue gas ready for sequestration. Oxy-fuel combustion has significant advantages over traditional air-fired plants. These advantages include:

- Flue gas masses and volumes fall by approximately 75%
- Due to reduced flue gas volumes, less heat is lost
- Flue gas treatment equipment can be reduced by 75%
- Flue gas is primarily CO<sub>2</sub>, suitable for sequestration and can lead to carbon credits
- The concentration of pollutants in flue gas is higher, which makes separation easier
- Most of the flue gases are condensable, which makes compression separation possible
- Heat of condensation can be captured and reused rather than lost in the flue gas

- Because nitrogen from air is not allowed to pass through a boiler, nitrogen oxide production is greatly reduced
- Fewer cutter stocks are needed for Fuel oil
- Nitrogen can be used for inerting, blanketing and catalyst circulation in refining applications

Nitrogen separated from oxygen during the process is regularly used in industries for several purposes. Typical applications include inerting, i.e., a method used to generate hydrocarbon/combustion-free atmospheres by purging the vessels with nitrogen before releasing for maintenance. Moreover, nitrogen can also be used to blanket vessels/tanks to prevent air breathing. Nitrogen is required for catalyst circulation from reactors to regenerators by creating fluidization (easy to move than solids by aeration) and inerting different atmosphere in process. Thus separating nitrogen will help to reduce NOx emissions and used effectively in industry.



Oxy-fuel combustion uses pure oxygen to produce electricity instead of ordinary air, which cuts nitrogen from passing through the process and reduces the volume of CO<sub>2</sub> emitted.



Yanbu' Refinery Department and R&DC are working to pilot a project utilizing oxy-fuel combustion, which can curb emissions. (Photo Source: Yanbu' Refinery)

# Saudi Aramco develops environmentally friendly high performance drilling chemicals

By John A. Hall, EPD and Gasan Alabedi, R&DC

Drilling for oil and gas can demand use of large quantities of chemicals. Even under the strictest of containment scenarios, drilling chemicals may find their way into the environment.

As we explore more challenging drilling horizons in frontier areas, higher drilling temperatures and pressures can be encountered. High temperatures increasingly encountered in oil and gas wells can approach or exceed 300 °C, which is much higher than temperatures in the deep fat fryer in your kitchen or restaurant (170-190 °C). Organic molecules in drilling fluids quickly degrade (think “cook”) at those temperatures. Traditional drilling chemicals that hold up well in higher temperatures may not be biodegradable, not a good trait when we want chemicals entering the marine environment to break down quickly to avoid any long-term effects. Another characteristic the company needs

from chemicals is for them to do their job — be chemically active to help produce oil. The more chemically active the material we use, the more toxic it may turn out to be. When developing new technically advanced drilling chemicals, it is a good opportunity to design in environmentally responsible characteristics. That’s exactly what the company has been up to, and new patents are likely on the way.

A member of the EPD’s Marine Environment Protection Unit has taken the lead in a project with the R&DC Department. This project is in collaboration with two out-of-Kingdom professors and three post-doctoral researchers at the world-class University of Durham in the U.K. The team has looked at totally different materials that have never been researched from a drilling fluids perspective, and though it is too soon to disclose the exact chemistries and possible outcomes (five

patents were recently filed with the US Patent and Trademark Office), they have discovered a new family of drilling fluid viscosifying agents (thickeners) and a new group of easily and cheaply produced surfactants.

This formal piece of the project ended at the end of 2015, but the work on further patents continues, with 11 further discrete pieces of Intellectual Property to be assessed by company patent experts and Intellectual Property Counsel. Once protected by patents, the process of commercialization can begin to bear fruit and help further reduce the company’s environmental footprint.

#### *Acknowledgements:*

*The author thanks EPD for the permission to work alongside RDC to perform this research and development work, and the time permitted to write this article.*





# Clean slate: volunteers flock to Saudi beaches to remove trash

By Ronald Loughland, EPD

On Saturday, March 26, the Society of Advocates & Volunteers for the Environment (SAVE), a self-directed environment group, conducted a beach cleanup and mangrove planting campaign in partnership with Ras Tanura Producing Department on Abu Ali Island, which is a Corporate Biodiversity Stewardship Area. Abu Ali Island is an ecological hot spot for biodiversity, with threatened mammal species such as the Golden Jackal still existing there. Abu Ali also contains many species of salt tolerant plants. The team of 60 people visited mangrove plantation areas on the island, artificial flamingo nest sites that have been developed to encourage flamingoes to nest, and cleaned over 1 ton of rubbish from the island's beaches.

On Friday, April 1, 2016, the Society of Petroleum Engineers (SPE-KSA) in partnership with SAVE conducted a coastal cleanup event along the coastal dunes at Half Moon Bay. More than 200 participants, including individual volunteers and families, participated in the event, with ages ranging from 4 to 60 years old. The cleanup started at 3 p.m. and lasted for three hours. During this time, volunteers collected more than 2 tons of rubbish from the dunes. Both events focused on raising awareness about the issue of rubbish, particularly plastic that litters the Kingdom's shorelines and desert environments. Plastic is a persistent pollutant, taking many years to break down under natural conditions.

Once broken down, however, these micro-plastics can enter the marine food chain, causing widespread contamination, including our food supply via seafood consumption. Beach cleanups such as these are part of several projects Saudi Aramco volunteer groups are undertaking to protect the environment and promote awareness among the community. These volunteers are demonstrating the company's core value of citizenship.



**Success!** Congratulations to all who participated in the Half Moon Bay cleanup. (Photo Source: Mohammed Al-Yousif, EPD)



**Planting our future.** Volunteers plant mangrove seedlings to help build Saudi coasts and marine ecosystems. (Photo Source: Mohammed Al-Yousif, EPD)

# Water works: Subsurface irrigation in Rub’ Al-Khali may enhance plants and wildlife

By Abdulrahman S. Ghamdi, EPD

Ever wonder when crossing the Saudi desert why vegetation can spring up in some parts while just down the road all you see are shifting sands? Well, while the climate may be uniformly dry at eye level, there are underground water sources out there that may help Saudi Aramco with its irrigation needs.

It has been noticed that in the Rub’ al Khali different types of plants grow out of thin layers of sand at the foot of sand dunes (Figure 1) or out of thin layers of sand found on salt flats, or sabkhas (Figure 2). What’s striking is that these plants are able to grow with the absence of irrigation.



Figure 1 : Plants grow at the foot of a dune in the Saudi desert (Photo Source: Abdulrahman S. Ghamdi, EPD)



Figure 2 : Plants on a sabkha absorb moisture from below and thrive in arid environments. (Photo Source: Abdulrahman S. Ghamdi, EPD)

So how can plants grow out of a thin layer of sand in a desert without irrigation? The idea EPD is currently exploring is that those plants root systems may be absorbing soil moisture generated through an evaporation process, which may help bring greenery to the desert.

When rain falls, it accumulates as shallow groundwater on sandy patches at the bases of dunes or over salt flats. When groundwater — driven up into the soil by capillary forces — evaporates, it brings up moisture in the upper parts of the soil. All that

is required is a thin shallow layer of clay underlying sand/soil for the water to collect and begin evaporating, bringing moisture up — just enough to support plant life. Even in areas of high salinity, the evaporation of the shallow groundwater can bring saltfree moisture from beneath and leave the salt down below. Rain is the major source of water for plants growing in the Rub’ al Khali sands. While rainfall is rare there, when it does occur it can be heavy. Don’t expect rolling green fields to cover deserts just yet, but there are plans under

consideration to study this hypothesis and to determine whether it does, indeed, support vegetation growth in such areas. If successful, results from this study may help to turn dunes and sabkhas into more hospitable habitats by carefully selecting suitable natural locations or even by engineering sites by adding clay, gravel, and sand, to encourage shallow groundwater accumulation and evaporation. And aside from rainwater, this subsurface irrigation effect can rely on applied brackish and even reclaimed waste water for growing native plants in

the area. There will be no sprinklers, valves, spraying water or mechanical sounds. Figure 3 (A layer of sand, or dry zone, can support plant life. Rain water can evaporate, bring water up from the moist capillary zone below).



Figure 3: The capillary effect can draw moisture from below and support plant life in the desert.



Figure 4 : A look at different design layers that encourage capillary mechanisms.

Furthermore, a lack of irrigation pumps, sprinklers or valves and other metal parts eliminates the possibility of corrosion. Figure 4 illustrates potential design layers to encourage capillary mechanisms. The outcrop of the sabkha is the Neogene Marl, which is a very low permeability rock. The sabkha will be covered by a very thin layer of clay to prevent fractures in the process so that no water is lost. In addition, the sabkha is flat, which will allow for equal water distribution. A thin layer of gravel will increase conductivity, maintain velocity for upwardly moving water and trap out salt over time. The sand will be above the gravel won't have to be too thick to encourage the process, ranging from 50 centimeters to 1 meters.

# Safe and sound: Saudi Aramco environmental health inspections hit the high seas

By John Love & Tom Hullock, EPD

Saudi Aramco has long worked hard to make sure its dining facilities across the Kingdom meet national and international environmental health standards. Still, not all Saudi Aramco facilities are the same; in fact, some fuel up and ship off to distant ports at home or abroad or involve offshore oil and gas operations. With that in mind, the Marine Department in 2015 requested the assistance of the Environmental Protection Department to conduct a training workshop for the Marine Department's vessel inspectors, who scrutinize approximately 300 vessels under the Marine Department's quality assurance scheme. To raise the bar even higher, these inspectors will now incorporate environmental health interventions into these assessments.

The Environmental Protection Department created a bespoke workshop for the Marine Department that specifically addressed environmental health hazards faced on marine vessels, with a focus on food safety. The training provided essential awareness to 35 inspectors to enable them to provide critical support services, to ensure food safety risks remain mitigated in offshore operations, where, due to isolated work environments, any spread of onboard illnesses could have severe consequences.

The course provided training to identify food safety hazards and help inspectors to understand and implement effective control measures such as:

- Time/temperature control, a powerful measure to control bacterial multiplication in the storage, preparation and service of food
- Temperature control of perishable food products, which is vital to preventing food poisoning and limiting bacterial growth
- Thorough cooking and reheating of food, which ensures the majority of harmful bacteria is destroyed
- Rapid cooling of food, which ensures that any bacteria surviving the cooking cycle are not allowed sufficient time to multiply

The training session tailored coursework to marine work environments. Take cross-contamination control, which addresses how raw meats are handled by food handlers or where raw foods may come into direct contact with cooked or ready-to-eat foods. Ideally, raw meat areas should be completely separated from areas where cooked foods are handled. This scenario is not always possible aboard vessels, because of smaller galley sizes, so rigorous cleaning and time-based control of operations must be used instead.

The training addressed personal and hygienic practices suitable for shipping operations as well. Inspectors learned how to make sure that infected individuals and even chronic carriers of disease are excluded from food handling areas. Food handlers with cuts, sores or abrasions on their hands should not handle food unless such ailments are treated and covered, as discharge can contaminate food with food-poisoning bacteria. Even healthy individuals can carry germs in the nose, throat, skin, and bowels, so all staff handling food should take every precaution to ensure that food remains hygienic at all times. A few simple rules are necessary, and all who are involved in handling food onboard must abide by them. Scrupulous personal cleanliness is essential to clean food handling, and the highest standards must be achieved and maintained at all times by those responsible for food storage, preparation, cooking, and service. Hands should be washed with soap in hot water and rinsed thoroughly in a wash hand basin designated specifically for

such use. Hands should be thoroughly dried preferably with paper towels, which is especially important since bacteria can grow in moisture. Rodents and insects can also spread diseases, so the training included advice on pest proofing the galleys to prevent food contamination. The program also covered adequate provisions for the disposal of refuse and waste onboard to prevent attraction of pests, especially at port, and the undertaking of pest control surveys on vessels at regular intervals to identify problems so action can be taken quickly to treat areas affected by pests.

The Environmental Protection Department's Environmental Health Unit (EHU) conducted the practical food hygiene inspection demonstrations in the galley of a supply boat berthed at the Tanajib Marine Department Pier, illustrating to vessel inspectors the best practices used to implement the food standards outlined under the Saudi Aramco Environmental Health Code. The workshop was very interactive and included a food safety quiz at the end to highlight areas covered. Feedback from the event was very positive, with participating inspectors indicating they had learned food-safety inspection techniques and principles that will enable them to carry out their new food-safety roles.

The Environmental Protection Department is proud of its new workshop, which empowers proponents to conduct environmental health inspections of their own facilities — driving performance, while ensuring that anyone using company-owned or contracted facilities are protected from preventable disease.



An EPD inspector monitors temperature of food in a Saudi Aramco vessel's galley. (Photo Source: Tom Hullock, EPD)



Vessel inspectors, EPD scientists and galley cooks participate in the practical workshop on board a vessel berthed at Tanajib Pier. (Photo Source: Tom Hullock, EPD)

# Hazards ahead: Saudi Aramco updates HazCom program — what you need to know

By Noujoud A. Nawwab, EPD

Saudi Aramco’s efforts to reduce occupational health risks associated with working with chemicals went through a recent overhaul, which will affect a broad range of company operations. On November 1, 2015, EPD announced changes to GI 150.100 “Hazardous Materials Communication (HazCom) Program.” This program aims to minimize occupational health risks associated with the use, handling and storage of chemicals. The HazCom program’s requirements include proper use and observation of Chemical Inventory Assessments (CIAs), Chemical Hazard Bulletins (CHBs), Chemical Hazard Communications Labels, Chemical Hazard Awareness Training and other written programs. The new requirements took effect on January 1, 2016, and included comprehensive revisions that:

- Reflect the recommendations of the Hazardous Chemicals Taskforce
- Update definitions and terminology to be in line with national and international standards
- Clarify stakeholder responsibilities
- Incorporate forms to standardize HazCom documentation across proponents’ operations

Changes are substantial and may affect day-to-day operations. The following table reflects the updated requirements in addition to the new requirements added to the GI.

| Section   | Old Requirement  | Updated Requirement  |
|---|--|--|
| 2.0 Definition                                      | <b>Chemical Risk Assessment (CRA)</b><br>A formal comprehensive record assessment of the handling and use of all hazardous materials at Saudi Aramco facilities.   | <b>Chemical Inventory (CI)</b><br>A formal record for all hazardous chemicals at Saudi Aramco facilities   |
|   | Material Safety Data Sheets ( <b>MSDSs</b> )   | Safety Data Sheets ( <b>SDSs</b> )   |
| 3.1 Chemical Hazard Bulletins                       | Proponent shall <b>post</b> relevant CHBs, or MSDSs on a bulletin board  | Proponents are required to <b>ensure</b> the CHBs or SDSs are available in the areas where the materials are stored/used   |
|   | Laboratory reagents, medicinal packages and small containers such as aerosols that are adequately labeled by the manufacturer <b>will not require CHBs.</b>  | Proponent shall send to EPD a copy of the SDSs for any supplied chemical <b>including</b> the laboratory reagents, medicinal packages and small containers such as aerosols that are adequately labeled by the manufacturer. |
| 3.1 Chemical Hazard Bulletins & 3.3 HazCom labeling | EPD shall update the CHBs <b>&amp; labels every 3 years or sooner</b> whenever there is a change.  | The CHBs & labels will be updated as <b>needed</b>   |
|   | Material Supply shall assign SAP stock number for each CHB and shall annually send an updated list of SAP stock numbers with corresponding CHB numbers <b>proponent organizations for their reference and use.</b> | Material Supply shall assign SAP stock number for each CHB and shall annually send an updated list of SAP stock numbers with corresponding CHB numbers <b>to EPD for inclusion on EPD’s website</b>                          |

| Section                  | Old Requirement   | Updated Requirement  |
|--------------------------|---|--|
| 3.2 Chemical Inventory   | Proponent shall provide an inventory of all hazardous chemicals to EPD/ECD Industrial Hygiene <u>every year</u>   | The proponent shall provide an inventory of all hazardous materials to EPD <u>every six months</u> .   |
| 3.3 HazCom labeling      | Material Supply shall arrange printing and shall maintain stock of the printed HazCom labels <u>as developed by EPD</u>   | Material Supply shall arrange for the printing of adhesive Hazcom labels for <u>all 9CAT and 9COM purchased labels</u>   |
|                          | Material Supply shall affix the HazCom labels to the appropriate <u>non-transient</u> stock containers before dispatching   | Material Supply shall affix the HazCom labels to the appropriate <u>transient</u> stock containers before dispatching  |
| 3.4 HazCom Program Audit | Proponents shall conduct an internal audit of the HazCom program <u>not less than annually</u>  | Proponents shall conduct an internal audit of their HazCom program <u>not less than every six months</u>   |
|                          | Proponents <u>will re-audit all proponents every three years</u> as part of the Occupational Health Hazard Assessment (OHHA) Program  | Proponents shall assess all proponents <u>on an as needed basis</u> to assure that all elements of the HazCom program have been implemented.   |
| 3.5 Training             | Proponents shall ensure that all Saudi Aramco employees who will be working with hazardous materials are fully trained by attending a classroom CHAT <u>every three years</u> | Proponents shall ensure that all Saudi Aramco employees who will be working with hazardous materials are fully trained by attending a classroom CHAT course <u>prior to their assignment</u> |
|                          | Proponents shall ensure all company employees take the e-learning refresher <u>every three years</u>  | Proponents shall ensure all company employees take the e-learning refresher <u>annually</u>  |

### TURBINE & ENGINE OILS

إرامكو السعودية  
Saudi Aramco

UN number: None  
HAZCHEM: None

1 **HEALTH HAZARDS**

1 **FLAMMABILITY**  
LOW

0 **REACTIVITY**  
UNSTABLE IN THE PRESENCE OF INCOMPATIBLE MATERIALS. PRODUCT IS CONSIDERED STABLE. HAZARDOUS POLYMERISATION WILL NOT OCCUR.

**FIRST AID:** Wash with running water.; Give water (if conscious). Seek medical advice.; Fresh air. Rest, keep warm.; Remove contaminated clothing. Wash with soap & water.

## CHB 904

For further information call Environmental Protection: 880-9714 (DH), or 427-0158 (JID)  
For proper disposal methods and locations for the chemical or chemical contaminated material, contact the Environmental Engineering Division, 880-9767  
**NFPA Rating: 0: Minimum, 1: Low, 2: Moderate, 3: High, 4: Extreme**

### TURBINE & ENGINE OILS

إرامكو السعودية  
Saudi Aramco

UN number: None  
HAZCHEM: None

1 **مخاطر صحية**

1 **قابلية الاشتعال**  
واظني

0 **التفاعل**  
يوجد مواد غير ملائمة. المنتج يعتبر مستقر. مخاطر البلمرة لن تحدث

**FIRST AID:** يُغسل بالماء الجاري. إقم بإعطاء الماء (في حالة الوعي). الجأ للمشورة الطبية. إخرج إلى الهواء الطلق. ازم الراحة والدفع. إزغ. إغسل الملابس الملوثة. تُغسل بالماء والصابون

## CHB 904

المعلومات الإضافية إتصل بإدارة حماية البيئة : 880-9714 (الظهران) أو 427-0158 (جدة)  
لمعرفة طرق و أماكن التخلص الصحيحة من المواد الكيميائية أو المواد الملوثة بها اتصل بقسم هندسة البيئة على الهاتف رقم 880-9767  
تصنيف **NFPA**: اثنى: 1؛ منخفض: 2؛ متوسط: 3؛ شديد: 4؛ شديدة جدا: 0

| Section                  | Additions  |
|--------------------------|--|
| 2.0 Definition           | The secondary container definition   |
| 3.2 Chemical Inventory   | An updated inventory shall be forwarded to EPD   |
|                          | Proponents shall assign an individual responsible for the chemical inventory maintenance   |
|                          | Maintaining the chemical inventory is detailed in this section   |
|                          | Storage requirements referral to the safety construction manual  |
| 3.3 HazCom labeling      | New labeling requirements for bulk transportation  |
|                          | New labeling requirements for secondary containers   |
| 3.4 HazCom Program Audit | Proponents shall submit copies of their internal audits to EPD every six months  |
|                          | Proponents shall document training records and classroom training  |
|                          | Proponents provide awareness training to contractors covering as minimum CHBs and labels   |
|                          | Certified trainers shall participate in online CHAT refresher annually to maintain their TTT certification   |
| 3.6 Written Program      | Proponents are responsible for ensuring that contractors working in their organization comply with the minimum requirements of this GI particularly the development and implementation of a written HazCom program |





# Putting on air: New health recommendation may affect how long respirators may be used on the job

By Francisco Estevez, EPD



A new recommendation out of the U.S. may affect how long Saudi Aramco employees and contractors may use respirator cartridges on the job, specifically by requiring they be changed out more often. The National Institute for Occupational Safety and Health (NIOSH), a U.S. federal agency that studies ways to prevent work-related injury and illness, recently added new compounds to its list affecting breakthrough times and service lives of air-purifying respirator cartridges, filters and carbon beds. (A breakthrough time is the time following the first and continuous use of a cartridge, after which the user might be exposed to harmful vapor due to waning effectiveness, while service life measures breakthrough time with possible safety factors applied).

Specifically, NIOSH recently updated its “MultiVapor” computer software by adding 66 new compounds to

the list affecting respirator safety, including toluene diisocyanate (TDI), methylene bisphenyl isocyanate (MDI), and Styrene to the software’s library. MultiVapor intends to help industrial hygienists or other qualified persons set cartridge change-out schedules, and new compounds may mean respirators may need to be changed with greater frequency. NIOSH’s updated software also features typical organic vapor cartridge parameters that are more representative of commonly used cartridges.

A primary objective of any occupational health program aims to prevent adverse health effects. When a material becomes airborne, or dangerous concentrations of gases and vapors are present, the primary means of preventing injury is through the use of engineering and work practice control measures. When such measures are not feasible, or when controls are in implementation stages or even during emergencies, appropriate respirators should be worn by workers when conditions merit. Air-purifying respirators protect against certain gases and vapors by using various chemical filters to purify the inhaled air. They differ from aerosol filters in that they use either cartridges or canisters containing sorbents or catalysts that remove or detoxify, respectively, harmful gases and vapors. Sorbents are usually granular porous materials that interact

with the gas or vapor molecules to remove them from the air. Catalysts chemically react with harmful agents to form less toxic products; for example hopcalite converts carbon monoxide into carbon dioxide. The cartridges and canisters may be replaceable, or the entire respirator may be disposable. When respirators are used, a formal, effective, and complete respiratory protection program is required. If respirators are to function as designed, they must be properly selected, fit-tested, maintained, and used by trained employees. Because of medical or even psychological conditions not everyone may wear a respirator. Respirators may interfere with vision or voice communications. They can also be hot and cumbersome to wear. These difficulties make respirators the least satisfactory method of control. Despite these difficulties, respirators are the only feasible protection in many cases. To effectively use a respirator requires a well-managed, complete and systematic program that includes MultiVapor alongside other elements such as broader equipment training procedures and exposure assessments, as even with the most efficient respirator, inhalation exposures are reduced, but they are not completely eliminated. NIOSH states that the software should not be used as a substitute for regulatory requirements or professional judgments.

# In Depth



# Dust in the wind: a look into dust and sand storms and their impacts on the Saudi environment

By Jumaan Al-Qahtani, Ioannis Alexiou and Ayman Al-Bar, EPD

## Introduction

Storms that kick up dust and sand across Saudi Arabia are often complex systems that can vary a great deal. Whether causing a nuisance or wreaking havoc on commerce, dust and sand storms impact large swathes of the Middle East each year, affecting safety, human health, local economies and environments in many ways. It should also come as no surprise that arid and semi-arid regions of the Middle East and the Arabian Peninsula often see especially intense dust and sand storms.

Dust formation is a complex atmospheric process influenced by both regional

and localized factors unique to each area such as soil characteristics, surface roughness, vegetation coverage, moisture, wind speed and direction. Anthropogenic dust emissions and activities such as soil disturbance may intensify this occurrence. Local climate conditions and prevailing wind regimes may also have significant impacts on the dust generation processes. And not all systems are the same. Take the dust storm. A dust storm is a phenomenon characterized by strong winds and dust-filled air over an extensive area. The term dust storm is more likely to be used when finer particles are blown

over long distances, especially when the dust storm affects urban areas. Dust storms are capable of transporting sediment over enormous distances, in many cases over thousands of kilometers far from their sources and in high elevations above the surface of the earth (4Km). Dust from the Sahara can be found as far away as Texas after traveling for up to 14 days. One prerequisite for the formation of a dust storm is a period of drought to provide fine dust particles. A dust storm is reported when the visibility is reduced to less than one kilometer.

## In Depth

A sand storm, meanwhile, has strong winds carrying large sand particles through the air. Sand particles carry diameters between 0.08 – 1 mm, and are confined very close to the earth's

surface, dipping down to 3.5 meters and rarely rising more than 15 meters above ground. The term sand storm is used most often in the context of desert sandstorms, or in places where

sand is more prevalent than dirt or rock. In addition to fine particles obscuring visibility, considerable amounts of larger sand particles are blown closer to the surface.



Sand storm over the desert

There is some confusion in literature between sand storms and dust storms. The former tend to be low-altitude phenomena of limited area extent and are predominantly composed of sand-sized materials. Dust storms reach higher altitudes, travel longer distances and are mainly composed of silt and clay. During the early stages of intense dust storms, both sand and dust particles are present in the atmosphere, though gradually, the finer dust particles end up prevailing in the air, as the coarser particles settle at the surface of the soil when wind speeds fall.

### Types of Dust/Sand Storms in Saudi Arabia:

Dust and sand storms that impact our region can be classified into four (4) types:

- Shamal – Frontal or thermal dust events (northerly winds)
- Haboob – Dust events caused by convective systems (thunderstorms)
- Dust whirls – Localized dust events
- Monsooning activity (westerly winds)

### Shamal/Northerly Winds

Dust storms caused by strong northerly winds are called “shamals” from the Arabic word for north. Sustained winds typically reach 30 knots, with stronger gusts to 40 knots. The dust front covers hundreds of kilometers and can last for several days — from 24 to 36 hours or even run from 3 to 5 days.

The major meteorological conditions causing dust storms in the Middle East are depressions (low pressure systems) moving eastward from the Mediterranean across Turkey, Syria, and Northern Iraq, associated with fast-moving cold air masses dipping down toward Saudi Arabia (frontal systems typical of winter).

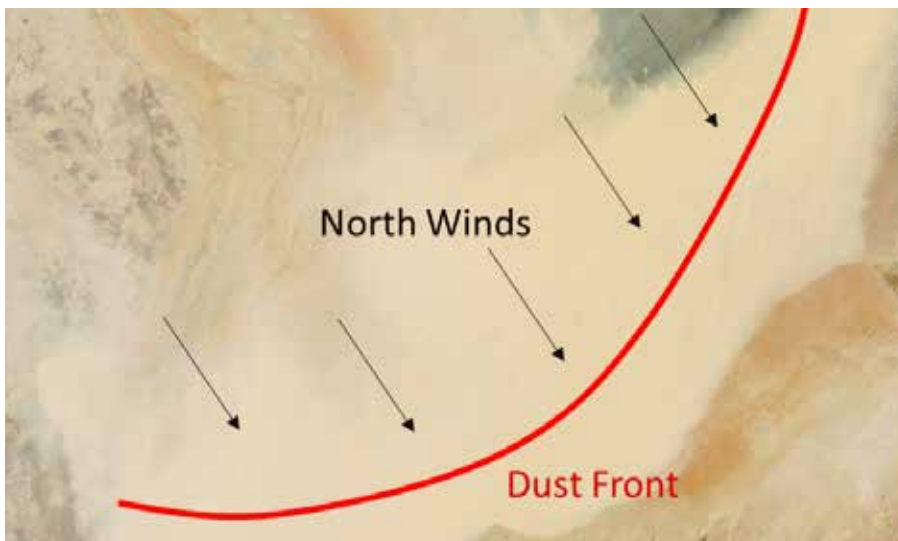
A second type of shamal sees winds lifting dust from Iraq, Iran, and adjacent regions. These systems are usually associated with areas of low pressure anchored over Southern Iran that form strong thermal gradients, due to very high surface temperatures interacting with a semi-permanent anticyclone over Northern Saudi Arabia. This zone between the two pressure systems induces high-velocity winds that transport dust across the region, extending from the Tigris–Euphrates floodplain. These types of dust storms occur predominantly in the eastern regions of Saudi Arabia during the summer (thermal type of dust events).

### Dust Whirls

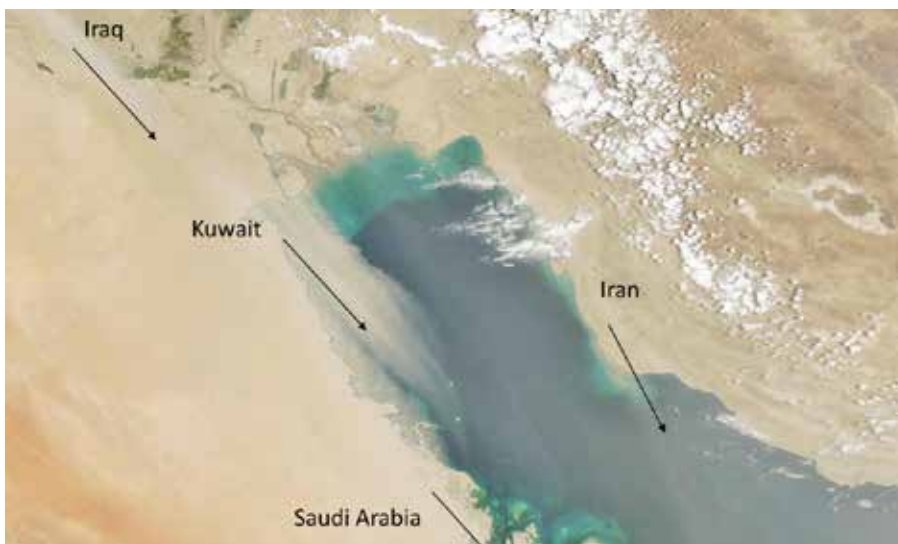
Dust whirls are exactly just that — whirling dust moving with the wind. They are usually less than 30 meters in height, but they may extend up to 300 meters or more, and are largely narrow systems that develop over heated surfaces, mainly in summer. They extend a few meters and normally persist for a couple of minutes.

### Haboobs

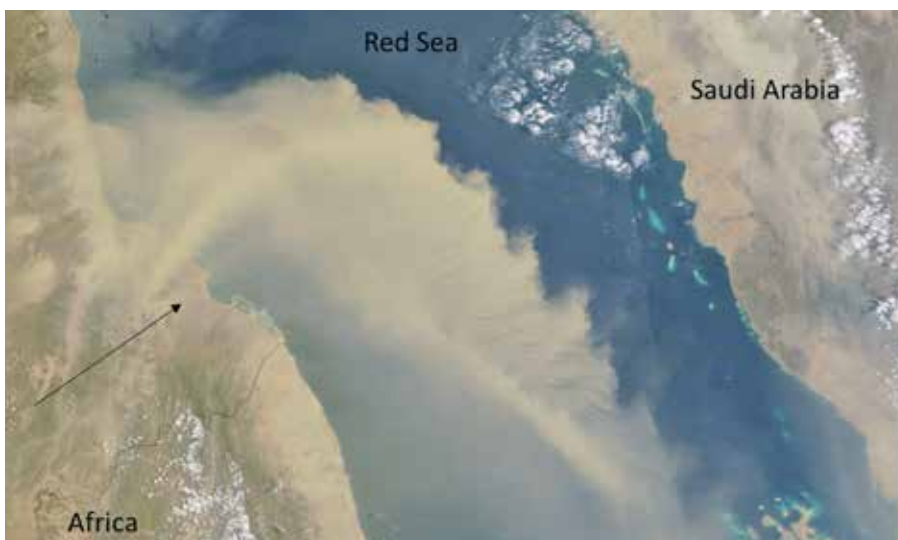
Localized, short-lived but intense dust storms, formed by downburst winds in thunderstorms, are called haboobs. The



Shamal frontal dust event. Image Source: NASA



Shamal thermal dust event. Image Source: NASA



Monsooning dust. Image Source: NASA

## In Depth

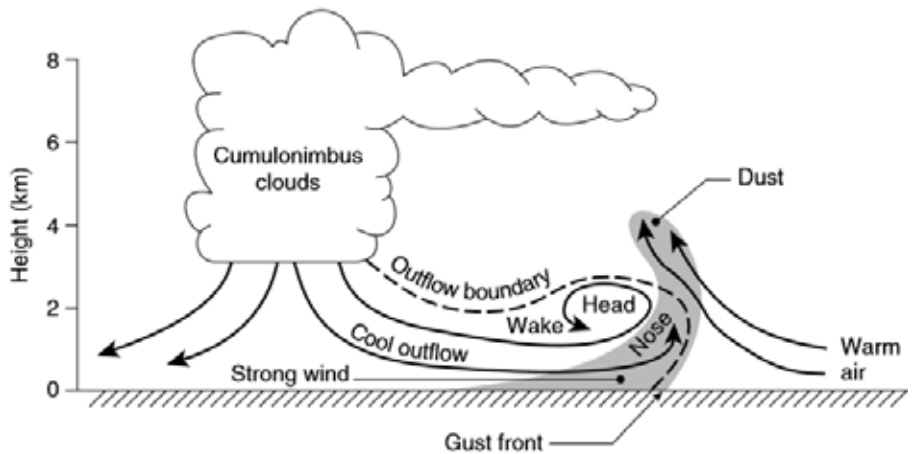
word “haboob” comes from the Arabic word habb, meaning “wind.” A haboob is a wall of dust as a result of microbursts or downbursts. Winds, associated with the dry downburst from a convective storm, average 35 to 50 knots (60 to 90 km/h). The air forced downward is pushed forward by the front of a thunderstorm cell, dragging dust and debris with it as it travels across the terrain. Haboobs are rather small-scale but intense phenomena, often covering 100 to 150 kilometers. These types of dust activities are present during the transition periods from winter to summer and from summer to winter.



Dust whirls. Source: NASA

### Monsooning Activity

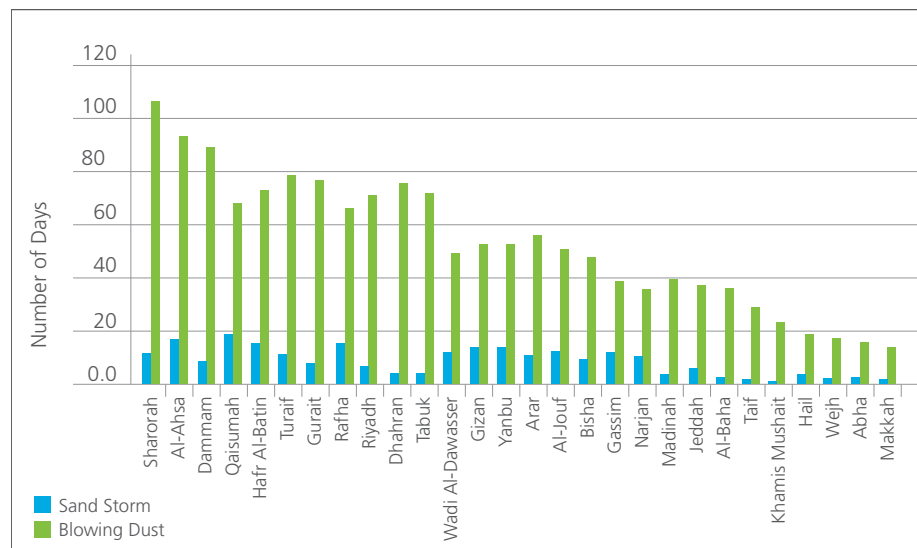
A fourth type of dust storm stems from monsooning activity, which is present mainly in the southern and western reaches of the Arabian Peninsula and the Red Sea during the onset of the summer monsoon season (May-September). Monsoons are marked by strong westerly and southwesterly winds due to the asymmetric heating of land and sea surfaces.



Haboob structure (Image Source: Desert Meteorology. Thomas T. Warner. 2004)

### Sand/Dust Storms Sources & Frequencies

The annual average days with dust or sand incidents can vary significantly within Saudi Arabia, rising as often as 110 days per year in Sharorah on the edge of the Rub’ Al Khali desert, to less than 20 days in Makkah. The following chart illustrates the yearly frequency of dust and sand incidents in various major cities. This variability in the annual frequencies of sand/dust storm events is mainly related to the proximity of these cities in large areas covered with sand (deserts) and the weather patterns causing strong winds.



Annual distribution of dust/sand events in KSA (Data Source: General Authority of Meteorology and Environmental Protection)

The main sources of dust in Saudi Arabia include deserts in the Arabian Peninsula, the Sahara, Iraq & Jordan, East Africa and some contributions from Iran. Saudi Arabian sources include mainly four (4) large deserts namely:

- Al Nafud Desert
- Ad Dahna
- Nafud al Dahi
- Rub' Al Khali (Empty Quarter)

Additional albeit smaller sand sources are present along the coastal areas adjacent to the Red Sea. Western regions are mainly affected by dust transported from the Africa's three major desert areas:

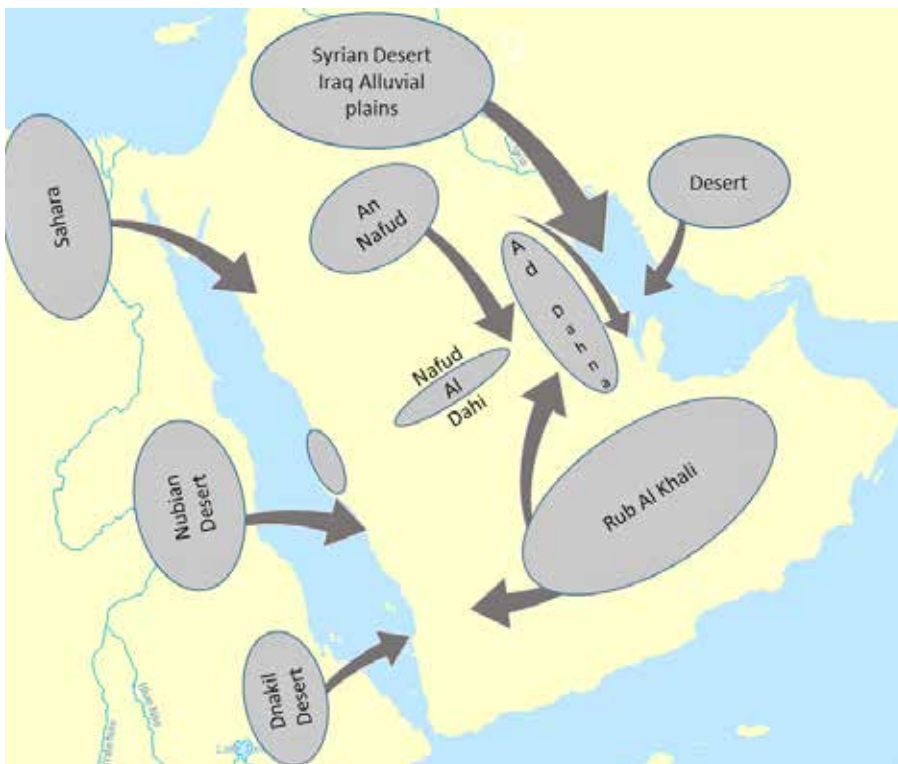
- Sahara Desert
- Nubian Desert
- Dnakil Desert

It is worth mentioning that North Africa and its deserts are considered the main dust emission source areas. Alone, this region generates over 50% of the total desert dust found in the atmosphere and almost five times as much as the Arabian Peninsula, which is the second biggest source.

### Impacts (Negative and Positive)

Both dust and sand storms bring about a very wide range of environmental impacts, which involve not only reduced visibility and other safety hazards, but others that have adverse effects on human health.

A number of medical conditions can be traced to desert dust and the effects of fine, wind-born particles. The straightforward inhalation of these fine particles can cause bronchitis, emphysema and silicosis (occupational lung disease). Dust may also be otherwise contaminated, by organisms such as bacteria and fungi, as well as by toxic chemicals that can harm people when settling on the skin or swallowed or inhaled into respiratory passages. According to the World Health Organization, there is a strong correlation between increased levels of fine particles in the air and increases in health hazards such as heart disease, altered lung functions and lung cancer. Dust can bring about several benefits



Dust/sand sources in the Middle East

to the environment as well. For example, the fine particles can act as cloud nuclei and help in enhancing rainfall. Add to that, dust particles can offset global warming by reducing the earth's surface temperatures. Recent studies have indicated that atmospheric fallout, whether wet or dry, contributes significantly to the replacement of soils that have been depleted of particulate matter and of dissolved nutrients by erosion, especially due to logging or other site disturbance. Additionally, iron and other nutrients that enter ocean waters from dust deposition are important for the productivity of marine phytoplankton.

### Sand/Dust Storm Protection and Preparation.

As dust and sand storms incidents are very frequent in Saudi Arabia, proper preparation is key to reducing exposure and minimizing risks related to these events. The following list includes important steps that we all should follow for any outdoor activity during

stormy seasons:

- Be vigilant and informed by checking the weather forecasts, as meteorologists can predict the likelihood of sand storms. Adjust your activities based on these forecasts and definitely avoid outdoor exercise during dust/sand incidents.
- When traveling in dust/sand prone areas, be sure to carry if possible protective equipment (i.e., airtight goggles, masks, water). Protect your eyes and mouth by wearing goggles and a mask. Try to cover your ears to prevent sand blowing into them. Wet a cloth and tie it around your mouth and nose to prevent sand and dust particles from entering your lungs, and then try and breathe as normally as possible.
- Avoid sand storms whenever possible. If such a storm is visible on the horizon try to maneuver around it or even head in the opposite direction.
- If you are in a car during a sandstorm, you may be in danger, as visibility can be reduced significantly and drop very fast. The best advice is to make your way off the road at the

## In Depth

nearest safe opportunity and park on the side or at least reduce travelling speeds. Once you are safely off the road, close all your windows.

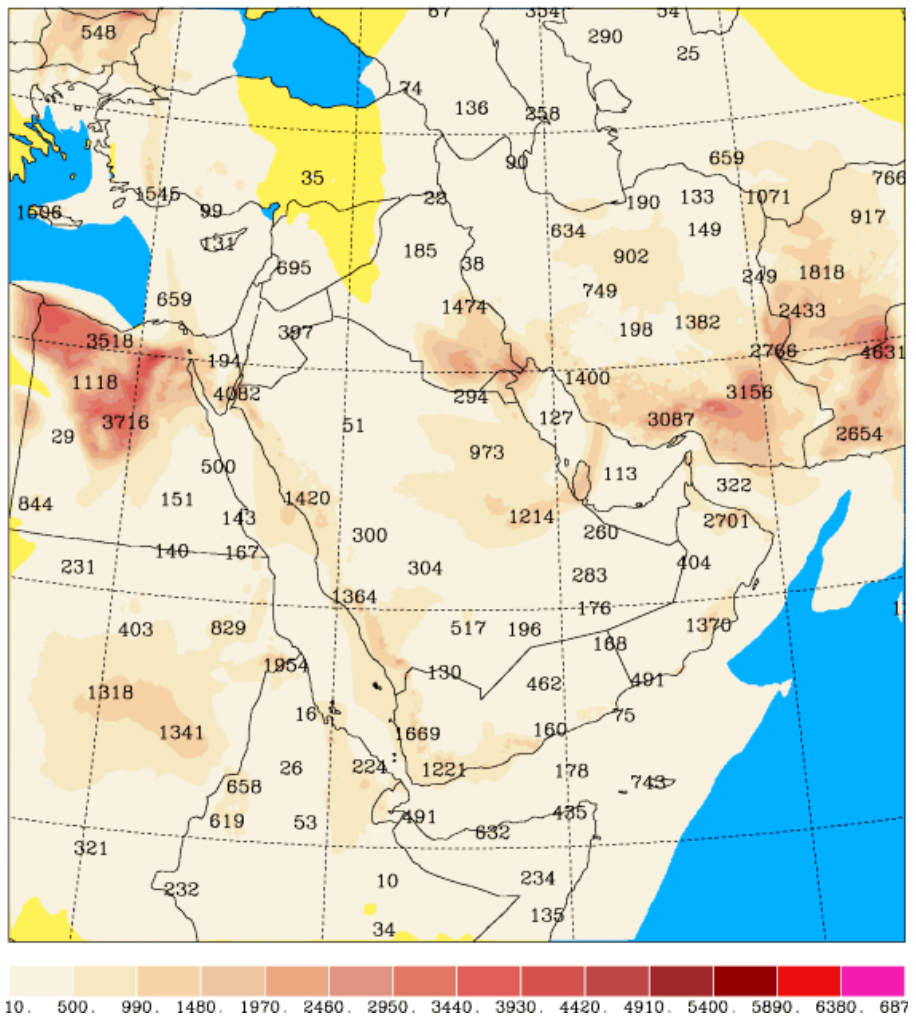
- If you get caught in a sandstorm while you are out and about on walks or treks, etc., find the nearest large land formation, such as a rock, and take shelter by the side of it. If you are unable to find a shelter quick enough, stay put and do not move. By moving you will put yourself at greater risk for potential hazards. You may also get lost.

### Understand the Mechanisms of Dust Storms in the Kingdom

To promote human safety and enhance forecasting capabilities for company operations either offshore or onshore and optimize planning, EPD has launched a sophisticated Weather & Sea State Forecasting System (WASSF). The WASSF forecast platform provides one of the most accurate dust storm forecasts for five days in advance, to support company operations and employees, as well as to better understand the basic conditions responsible for creating the Kingdom's dust storms. The system is available online for all Saudi Aramco employees at [www.wassf.net](http://www.wassf.net), and can be used as an advisory tool to anticipate dust/sand storms in terms of exact location and intensity.

### Aramco Fenced/Protected Facilities.

Saudi Aramco's fenced facilities provide sheltered environments to protect local desert vegetation. The fences act as protective barriers to overgrazing and outdoor human recreation activities. These protective areas maintain local plant growth and prevent wind erosion and land degradation, which can lead to dust/sand production.



10 Weather and Sea State Forecasting System (WASSF)

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# Artificial reefs: enhancing biodiversity in the Arabian Gulf

By Ronald Loughland, Diego Lozano-Cortes, William Bass, Ali Qasem and Alaa Elyas, EPD

Coral reefs are invaluable natural sources of ecological and economical richness. These ecosystems serve as nurseries for numerous marine species, provide shelter to more than 25% of all known marine fishes and act as natural barriers against coastal erosion. The flora and fauna inhabiting coral reefs are normally dependent on these hard substrates for growth and for this reason, space on which to live is often the most important limiting resource for coral reefs, as unoccupied hard substrates are generally scarce. In the marine environment, substrate areas available for colonization are either created naturally by disturbances that clear the benthos (e.g., storms

and hurricanes), or artificially by the immersion of structures in the water. In the latter case, artificial reefs have served as useful tools to promote the growth of marine life, mitigate impacts on natural habitats, and for tourism purposes by serving as dive sites. In the Arabian Gulf, the use of artificial reefs dates back to over a century, when different materials including date-palm trunks, stones and pottery were sunk in coastal areas to increase the abundance of fish for human consumption. Various kinds of disturbances, both natural and manmade, have impacted coral reefs worldwide, leading to their degradation and loss. The Arabian Gulf is not exempt to these unfortunate impacts,

with coral mortality attributed to increasing temperatures during recent decades. Prolonged increases in sea surface temperatures (SST) have resulted in wide-scale coral bleaching, which in turn has led to the collapse of many coral reef habitats. This phenomena has impacted not just coral reefs, but also the many diverse reef species, including fish that use the structures as refuges and feeding resources. Currently, most of the coral reefs in the Arabian Gulf are at risk of disappearing, due to a combination of climate-change factors and anthropogenic impacts (Fig. 2). Saudi Aramco is now restoring critical reef structures through an artificial reef initiative. Artificial reefs are also used



Figure 1. Healthy corals provide food and protection to different marine organisms, including fish species that we consume (Photo source: Marine Atlas Western Arabian Gulf, Loughland and Al Abdulkader 2011, Saudi Aramco).

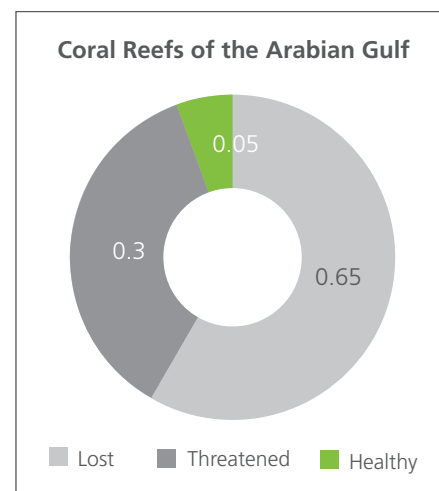


Figure 2. Percentage of coral reefs lost, threatened and healthy in the Arabian Gulf. Source: Data collected from Saudi Aramco and KFUPM following over 4 decades of marine studies and monitoring.

## In Depth

throughout the Arabian Gulf to mitigate impacts on coastal habitats and marine resources. These purpose-built structures provide hard substrates that are rapidly colonized by different fish and marine organisms, some of which serve as food for humans. There are two types of artificial reefs, those that are created intentionally with a specific purpose (planned) and those that occur accidentally (unplanned). Planned artificial reefs are engineered-designed structures built with specific materials and shapes that enhance the attraction of marine organisms. Unplanned artificial reefs are structures that are built for a different functional purposes but become habitats colonized by marine life; examples of these are break walls, ports, piers, offshore oil and gas facilities and sunken vessels.

In the Arabian Gulf there are thousands of oil and gas-related structures, such as well platforms, loading terminals, and pipelines that act as artificial reefs, by providing substrates for the development of marine communities. Due to safety and security protocols, human activities around these structures, are restricted, which prevents disturbances such as fishing around the marine communities living near these structures as well as in natural habitats surrounding these areas, therefore acting as de facto marine protected areas. Recently it was documented that there was a direct relationship between fish abundance and the number of oil and gas facilities occurring in the Arabian Gulf.

Alternatively, the use of purposebuilt reef structures for artificial reef development has been increasing recently in the Arabian Gulf, and some artificial reefs have been successful in attracting important marine organisms including corals and commercial fishes like the grouper. There has been a continuing effort since the 1970s to increase knowledge of marine biology in the Arabian Gulf, which has led to

the publication by Saudi Aramco of one of the earliest books in the region concerning marine and coastal natural resources “Biotopes of the Western Arabian Gulf” followed later with Saudi Aramco’s publication of the “Marine Atlas of the Western Arabian Gulf.” Saudi Aramco has also been actively promoting the growth of marine life, with both planned and unplanned artificial reefs. In addition to the offshore oil and gas facilities, Saudi Aramco sank two boats in the last two decades in an early attempt to establish artificial reef habitats in the Arabian Gulf. The first boat was the *Jana-2*, a 22m-long tugboat sunk 120 kilometers north of Dhahran in 1998. The second boat, the *Ma’agla-5*, a 16m-long pilot transport, was sunk 120 km north of Jubail in 2004 (Figure 3). Before sinking, the boats were cleaned from all harmful materials and were sunk in places with scarce corals and flat topography. Today,

now creating more permanent, stable and long-lived artificial reef structures throughout the Arabian Gulf.

Currently, there is an initiative underway from the Environmental Protection Department to install planned artificial reefs in strategic locations throughout the Arabian Gulf. To choose the best places to deploy these reef structures, a scientific-based study was conducted during Phase 1 of the project to identify the best locations in the Arabian Gulf for deployment. This study involved developing a matrix to evaluate over 80 sites along the Arabian Gulf coast from Safaniyah in the north to Al Qurrayah in the south. At each location, factors such as water depth, sediment type, existing habitats, coral cover, fish and invertebrate biodiversity, and proximity to Saudi Aramco offshore structures (protection from disturbances and leveraging existing benefits of structures



Figure 3. Photograph of the boat Ma’agla-5 before it was sunk in 2004 (image from the Saudi Aramco’s Dimensions magazine).

they host a diverse array of marine life. Although the boats provide good bases on which reef organisms can flourish, these structures tend to be short-lived and slowly disintegrate, with the base collapsing and the entire new reef also eventually collapsing. As a result, Saudi Aramco has advanced its approach in developing artificial reef habitats and is

and surrounding “protected areas”), were all assessed. The matrix allowed the sites to be ranked according to their suitability, and the best 25 sites were selected for Phase 2 of the project involving the deployment of 728 various artificial reef modules (Figure 4). There were 2 types of artificial reef arrangements in Phase 2 of the project.

The first configuration consisted of three distinct shapes (cubes, pyramids, and domes; Figure 5) forming small

reduces overall biodiversity on the artificial reefs. The second configuration was a mega reef array incorporating

of limestone corridors from the nucleus and outer circumference of limestone corridors connecting all satellites). The limestone corridors provide a good growing base and become ideal for providing a natural reef connection between the nucleus and all the satellite reefs hence allowing reef, organisms to move easily between different artificial reef structures, within the mega array. The mega reef array was developed at the best site identified by the matrix study from Phase 1, which was adjacent to Abu Ali Island. The deployment of the reefs at the 25 sites was completed in September 2015.

Seasonal monitoring of the 25 artificial reefs occurred in the winter months — 6 months following deployment and are again scheduled for the summer months, 12 months following deployment. The monitoring allows the various locations north — south, and the various shapes (i.e. cubes, pyramids, and domes) as well as the mega reef array with its limestone corridors to be evaluated. The evaluation examines productivity, species biodiversity and fish assemblages and numbers. According to data collected during the recent winter monitoring, the central part of the Arabian Gulf was the area with the highest abundance of reef fishes, the highest biodiversity of macroinvertebrates, and was the most productive in terms of epiphytic biomass.

The next phase in this project (Phase 3), has been developed to deploy additional mega artificial reefs arrays at nine additional ideal sites in the Arabian Gulf, using the best module shapes and configurations, as determined from the monitoring of the reefs deployed in the Phase 2 study. The reefs to be developed in Phase 3 will create new productive reef habitats, enhancing the Arabian Gulf's fisheries resources and offshore biodiversity, while also providing resilience to impacts from climate change.



Figure 4. Location of the 24 artificial reefs and the mega reef array near Abu Ali.

artificial reefs, which were used at 24 of the selected sites. These shapes were deployed as nested arrays, which involved placing smaller modules inside larger modules to provide a more complex reef structure (Figure 5). This eliminated large void areas that are often used by large predator fish, which

a nucleus of stacked cubes providing vertical relief, which was surrounded at 80m distance by 12 satellites of smaller reef modules of different shapes, all connected by continuous corridors of limestone baskets (1,291 baskets in total), with the overall array resembling a wagon wheel (i.e., radiating spokes

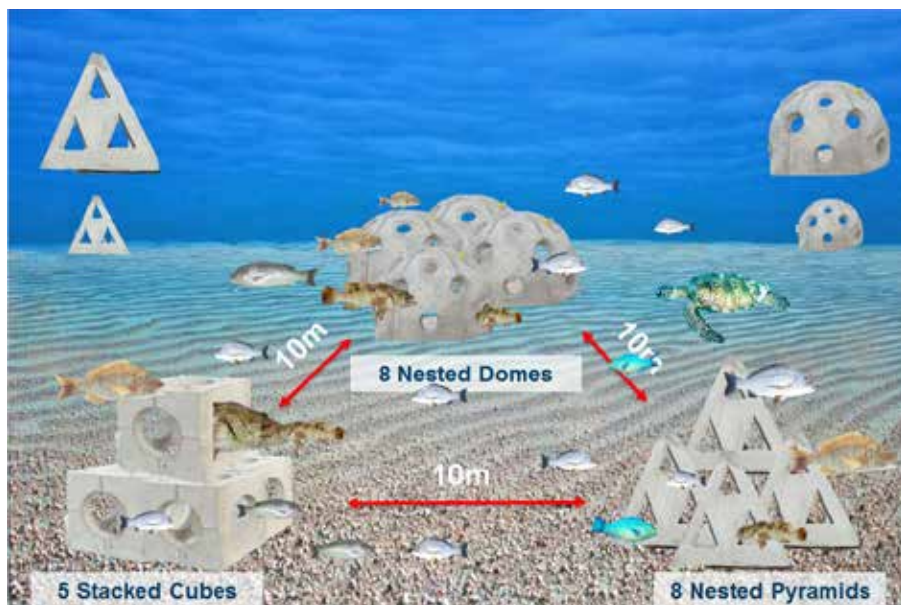


Figure 5. Artificial reef design for the 24 reefs, using three different module shapes (cubes, pyramids, and domes).

# Blue carbon: delving into Saudi Aramco's carbon sequestration potential

By Perdana K Prihartato, EPD

The burning of fossil fuels and the release of dust particles into the air from deforestation can generate greenhouse gas emissions, thus pumping carbon into the atmosphere. Carbon emissions generated from these two processes, known as “brown” and “black” carbons, contribute to rising global temperatures that can result in climate change (brown carbon includes emissions from burning fossil fuels, while black carbon includes dust particles and carbon emitted from land changes, such as deforestation, dredging, construction, etc.). Efforts must be made to keep global temperatures below the 2°C threshold above pre-industrial levels agreed upon at the COP21 Paris summit in 2015. Such a goal will become a reality by limiting a global carbon budget to 1 trillion tonnes. (A carbon budget caps how much in emissions an entity can release). To help the world achieve this goal, multiple steps must be taken, including mitigating emissions at their sources and other more adaptive ways, such as those that keep carbon stored in the globe's forests and their soils, thus preventing them from escaping into the atmosphere. Habitat conservation is still a tool of choice for both adaptation and mitigation approaches to dealing with climate change. Studies have shown that preventing degradation and restoring the lost habitats that can produce carbon-sequestering vegetation could cut carbon emissions by 25%.

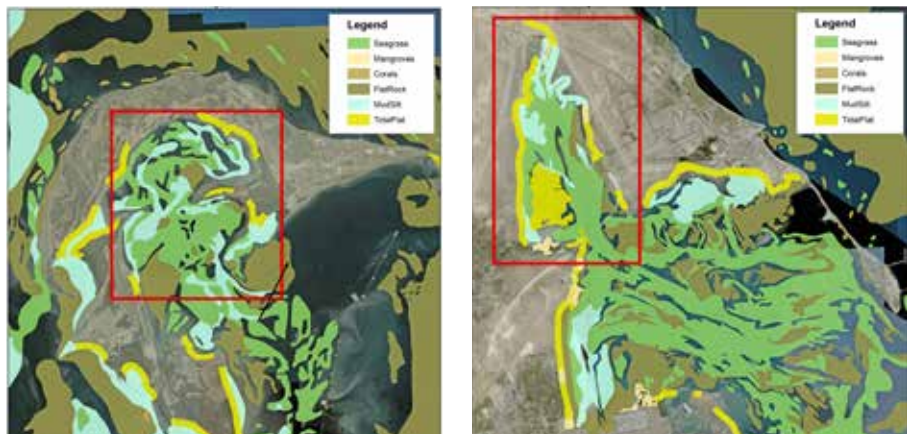


Figure 1. Biotope maps comprise of mangrove, seagrass, flat rocks, tidal saltmarshes (mudsill and tidal flat) showed in different colors. On the left panel is Abu Ali Island, and the right panel is Ras Tanura Eco-Park. The calculated habitats are limited to the red boxes.

While clearly lacking green Amazonian forests, the Kingdom of Saudi Arabia is blessed with coastal and marine ecosystems in both the Red Sea and Arabian Gulf, which are highly rich with biodiversity and exotic native species. Not only that, the critical role in capturing carbon in coastal and marine ecosystems has been vastly overlooked. Over half (~55%) of biological carbon (carbon captured by plants) is sequestered by marine flora, which is known as blue carbon. The ocean's vegetation, such as mangroves, salt marshes, and seagrass, which cover less than 1% of the world's seabed, account for more than 50% of all carbon storage in ocean sediments. These ecosystems often face great threats such as dredging and landfilling for urban and industrial development.

Saudi Arabia wants to reverse that trend. At the COP 21 climate change summit in 2015, the Kingdom's stakeholders, including Saudi Aramco, championed adaptation measures to reduce emissions. Blue carbon fits into that scheme as well, and today, Saudi Aramco is managing campaigns to plant mangrove seedlings, to increase blue carbon in corporate biodiversity projects such as the Ras Tanura Eco-Park and Abu Ali Island (Fig 1 and 2). To validate Saudi Aramco's efforts to protect and develop these ecosystems, the Environmental Protection Department conducted a preliminary blue carbon study that will later synergize with more comprehensive field and laboratory analyses, conducted in cooperation with King Abdullah University of Science and Technology (KAUST).

So far, blue carbon appears to serve as an effective tool for combating climate change. Habitat composition at the Ras Tanura Eco-Park and Abu Ali Island consist of mangrove (256.38 ha), seagrass (3279.03 ha), and tidal salt marshes (498.49 ha) (Fig. 2). By using literature references on carbon sequestration values at each of the habitats based on the Abu Dhabi Blue Carbon sequestration values (AGEDI, 2014), EPD has estimated that both the Ras Tanura Eco-Park and Abu Ali Island are sequestering ~1.2 million tons of CO<sub>2</sub> per year, which equals the emission of roughly 250,000 passenger cars per year under normal travel use (Fig. 3). Based on this preliminary analysis, EPD scientists have concluded that environmental stewardship projects, such as mangrove seedling plantings, conducted over the last 20 years, have contributed significantly to blue carbon’s potential. Add to that, by developing corporate protected biodiversity areas such as the Ras Tanura Eco-park and Abu Ali Island, Saudi Aramco greatly contributes to the Kingdom’s commitment to cutting emissions in line with the Paris agreement, and protecting the environment in all areas of operation. EPD expects reach its goal of planting 2 million mangrove seedlings in 2017.

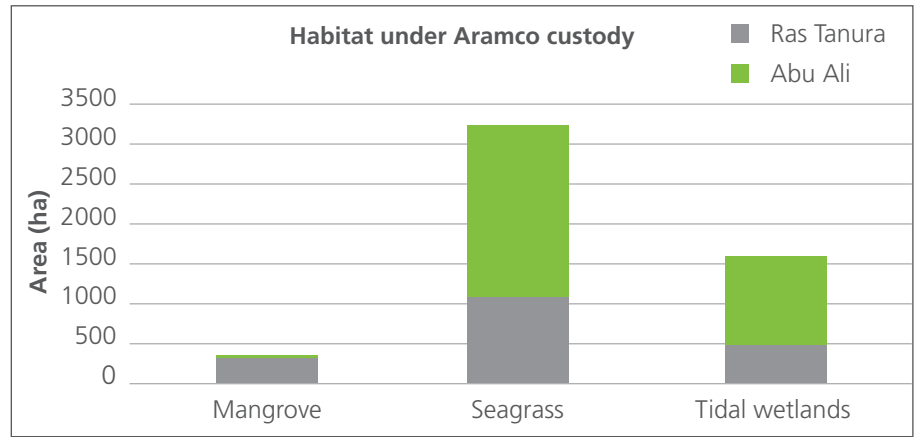


Figure 2. Habitat area in hectares million under Aramco custody for mangrove, seagrass, and tidal wetlands in the Ras Tanura Eco-Park and Abu Ali Island. Light grey represents Ras Tanura Eco-Park while the green represents Abu Ali Island as referred to the map (Fig. 1).

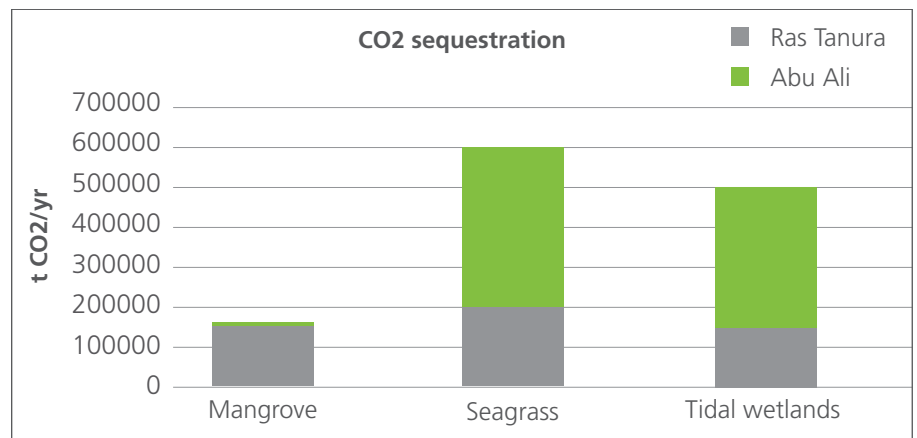
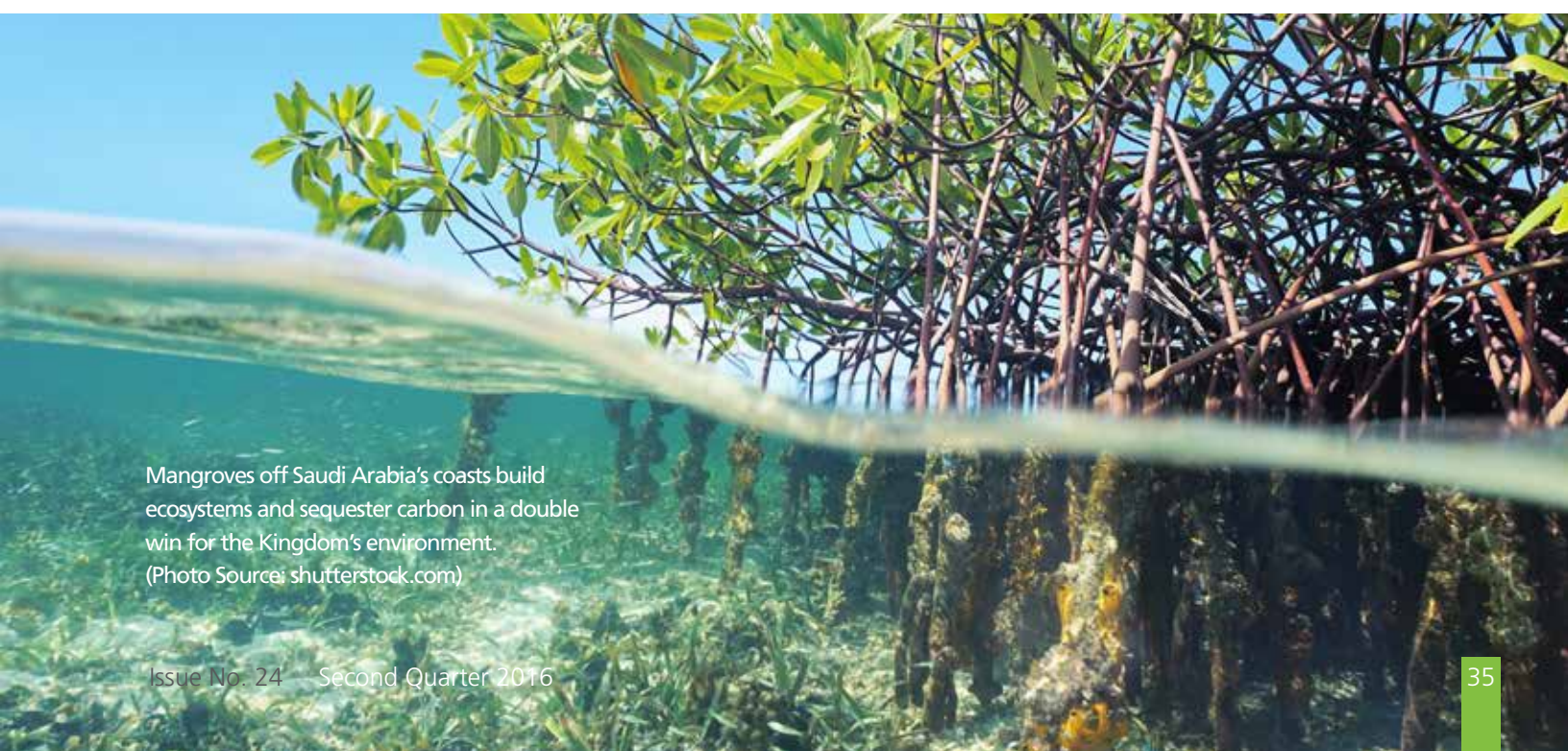


Figure 3. Sequestration rate in tonnes (tCO<sub>2</sub>/yr) at each habitat (mangrove, seagrass, and tidal wetlands) for Ras Tanura Ecopark and Abu Ali Island. Light grey represents Ras Tanura Eco-park, while the green represents Abu Ali Island, as referred to in the map (Fig. 1).



Mangroves off Saudi Arabia’s coasts build ecosystems and sequester carbon in a double win for the Kingdom’s environment. (Photo Source: shutterstock.com)

# How to minimize health impacts while welding

By Kent F. Strawn, EPD



A worker remains protected while arc welding, which welds metals using the heat generated by an electric arc. (Photo Source: Saudi Aramco)

The world is full of retirement-age people who regret not protecting their health when they were younger. And so it is with welders. It's well-documented that many long-term health problems associated with the profession are preventable. But, because the causes and incremental effects can be invisible, literally, they tend to be ignored, that is until welders grow older and the impact of that disregard can be ignored no longer.

It turns out those fumes inhaled through the years may cause serious medical complications. Epidemiology studies have shown that a large number of welders experience some type of respiratory illness. Respiratory effects seen in full-time welders have included bronchitis, airway irritation, lung function changes, and a possible increase in the incidence of lung cancer. Pulmonary infections increase in terms of severity, duration,

and frequency among welders. Although epidemiological studies have demonstrated an increase in pulmonary illness after exposure to welding fumes, little information of the causality, dose-response and possible underlying mechanisms regarding the inhalation of welding fumes exists. Even less information is available about the neurological, reproductive and dermal effects after welding-fume exposure. Moreover, carcinogenicity

and short and long-term toxicology studies of welding fumes in animals are lacking or incomplete. Therefore, an understanding of possible adverse health effects of exposure to welding

Even though air testing may determine these fume exposures are within current regulatory occupational limits, those limits are simply a guideline to help benchmark the airborne concentration.

highly toxic gas. The nose typically collects and filters much of the smoke, fumes and grinding dust welding machines create. But some welding-fume particles are very

### Avoid Gases and Fumes



Grinding of a metal weld point takes place in a safe and properly supervised manner. (Photo Source: Saudi Aramco)

fumes is essential to risk assessment and the development of prevention strategies and will impact a large population of workers. All too often seemingly insignificant job-related activities can compound and lead to illness in later years. The good news is you can reduce the risk of these ailments significantly by making a few simple changes to your daily routine, even when welding.

Sometimes you receive specific warning signs after inhaling gases and fumes. For example, if you breathe in enough zinc fumes while welding on galvanized metal, you may later experience metal fume fever. Symptoms include night sweats, chills and stomach pains. Or you may exhibit shortness of breath or headaches after breathing certain fumes.

You might inhale many gases and fumes over the span of your career that do not provide any obvious warnings.

They should not be considered an absolute safe level of exposure. Welding fumes are a combination of various metals. For instance, mild steel is mostly iron, but it also contains manganese, which has received a great deal of attention in terms of its effect on health. Stainless steel also contains iron as well as nickel and chromium. Each compound may have different health effects. Other injurious gases that may be produced during welding operations include nitrous gases and ozone. Oxygen and nitrogen in air passing through a flaming arc combine to form nitrogen oxides and ozone, which are potent lung irritants. Also, chlorinated solvents commonly used in industry that may contaminate surfaces to be welded may be decomposed not only by heat but also by the effects of ultraviolet rays. This decomposition results in the formation of more hazardous products like phosgene, a

small in size and can pass through the nose, the sinus cavity, down the throat and into the lungs. Most people never even notice an irritation. After years of inhaling welding fumes, you begin to exhibit signs. Symptoms can be as benign as breathing heavily after walking up a flight of steps, but the underlying problems can be much more severe. Being attentive to conditions and taking simple, preventive measures can greatly reduce the risks presented by gases and fumes. Here are some steps you can take to protect yourself:

- Keep your face out of the welding fumes.
- If there is a natural breeze blowing through the building, stand to the side so the breeze pushes the fumes away from your face. Don't block the airflow.
- Whenever possible, use a cooling fan to blow away fumes when there

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is no natural breeze in the building. Remember, you cannot be close to a large fan because the air current will remove the shield gas around the arc. Move the fan until you notice a very slight breeze. The breeze will not cool you, but it will help dissipate the smoke and fumes.

- Weld on clean metal whenever possible. Grind away coatings and paints from the area to be welded because they burn up and smolder, creating potentially harmful odors and gases. Also, metal parts should be thoroughly decontaminated before welding to remove all traces of solvents from their surfaces.
- Use local exhaust ventilation systems properly. Position the hood close to the weld and set up your workstation to allow gases and

stated earlier, particulates generated by welding and/or hot work with metals are considered potentially hazardous, especially in confined spaces with limited ventilation. Welder's masks or respirators can filter out the majority of the hazards (metal fumes), as some are fitted to work under the welding hood. In work areas where new construction/maintenance welding is done in any tank, boiler, or other inadequately ventilated confined space, where local exhaust ventilation is impractical, the welder and other workers should be protected by wearing appropriate respiratory protection and increased levels of dilution ventilation into those spaces.

the hazards associated with welding and related operations, safety is the key to protecting our health now as well as protecting our personal health protection for years to come. Efficiency and safety in the use of the many processes used in welding operations go hand-in-hand with the careful observance of suitable operating procedures and safe practices required in our work places. Following these common-sense precautions will protect against the risk of exposure to all principal hazards in the workplace, including welding operations. Comprehensive information on the welding and other hot-work safe practices and accepted procedures are available in the Saudi Arabian Standard Organization's standard: "Industrial Safety and Health Regulations –



A worker demonstrates the proper way to engage in arc welding, which welds metals using the heat generated by an electric arc. (Photo Source: Saudi Aramco)

fumes to be pulled away from your breathing zone.

- If you cannot use a cooling fan or exhaust ventilation system to capture the fumes, wear a particle respirator to protect your lungs. As

The Webster dictionary defines safety as a condition or state of being safe; freedom from danger or hazard; exemption from hurt, injury or loss; a means of protection; a safeguard. Thus, when considering

Welding, Cutting and Brazing" (SASO 336, GS 220). This information is available on ShareK, Industrial Hygiene Community of Practice.



# Cut your environmental footprint: tips on how to save energy at home

By Tareq Ajab Noor and Rabea A Faloudah, Yanbu Refinery

## Energy Conservation

Households rely on utilities such as electricity, natural gas and water services to meet their needs each and every day. You use these utilities to perform many daily tasks, from heating your home, to washing your clothes to running up the air conditioning in the summer. That's obvious. As the price of energy rises, so do the costs for these necessities, which is also obvious. Still, households must look for ways to cut their utility bills to save money, and that's where some not-so-obvious challenges lie. By practicing energy conservation, you can develop habits to reduce your energy usage and save money. Whether you own your home or rent, there are a number of things you can do to save on the energy you use

every day throughout your day.

**1. Create a "bright room" in your house.** When the sun goes down, turn on the lights in just one central room in your house and encourage your family to spend the evening hours there instead of scattering around the house and lighting up every room. Keeping the lights on in just one room will save a lot of energy and money over time.

**2. Turn off the lights, light up the candles.** Conserving energy means taking a new approach to everyday conveniences we take for granted, like the ability to flip on all the lights and keep them burning all night long. You don't have to completely stop using electric lights, but using candles instead

a few nights per week is a great way to save electricity and money as well as provide inspiration for reevaluating your approach to energy. In addition to these practical reasons for turning out the lights, breaking out the candles provides an instant atmosphere of romance or even spooky fun, depending upon whomever else is around to enjoy it!

- Start by choosing just one night a week to use candles instead of electric lights. Stock up on sturdy, slow-burning candles that will cast fair amounts of light for several hours.
- On "candle night" try to do activities that don't require electricity, such as



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telling stories or reading by candlelight.

- Be sure to store your candles and matches in a safe place when they are not in use.

**3. Embrace natural light.** During the day, think of the sun as your primary light source and rearrange your home or workplace to take advantage of its rays. Open the shades or blinds and let the light pour in instead of automatically flipping on the lamp switch.

- If you work in an office, try to arrange your desk so that it's lit by natural light, so you won't have to use a desk lamp or overhead lighting.
- In your home, set up your family's main daytime activity areas in the brightest room that gets the best sunlight. Drawing, reading, using the computer and other activities that require good lighting can take place in this room without the need for electric lights.

**4. Replace your incandescent light bulbs.** These old-fashioned light bulbs burn off most of their energy as heat instead of producing light. Replace

them with compact fluorescent bulbs or LED bulbs, both of which are much more energy-efficient.

- Compact fluorescent bulbs use about a quarter of the energy of incandescent bulbs. They're made with a small amount of mercury, though, so be sure you dispose of them properly when they burn out.
- LED bulbs are more expensive than the other types, but they last longer, and they don't contain mercury.

### 5. Minimize use of outside lights.

A lot of people don't think about how much energy porch lights or path lights consume, especially when those lights stay on all night long. Decide whether it's really necessary to leave the lights on past your bedtime.

- If you want outside lights for security purposes, consider buying an automatic light that operates using a motion detector rather than one that burns constantly.
- Turn off decorative holiday lights before you go to bed rather than waiting until morning.
- Replace path and garden lights with those that charge during the day and glow warmly at night.

**Winter Heating:** Turning up the heat in the winter months is necessary to keep out the cold weather. Still, there are a few simple ways for you to make sure your home is efficiently keeping the warm air in and the cold air out. Keep the thermostat set to 68 degrees Fahrenheit and set it back even more when you are sleeping or away from your home. You can purchase a programmable thermostat to automatically turn the temperature down at night or when you are not home. By turning down your thermostat one degree, you can save up to 3 percent on your heating bill.

Elsewhere, look for a furnace that is ENERGY STAR approved for energy efficiency. Make sure there is adequate insulation in your attic, walls, basement, crawl spaces and floors. You should also make sure access to your attic is insulated and weather-stripped.

Conserving energy is an important way to reduce strain on the environment and bring down electricity expenses. Taking measures like reassessing how much you need to use appliances, using lights only when necessary, and insulating your home can go a long way toward shrinking your carbon footprint — and your utility bills.



# The VOC pathfinder: new technologies for detecting and reducing emissions of volatile organic compounds

By Khalid Al-Binali and Rafik Djouad, EPD

Volatile Organic Compounds (VOCs) are of particular interest because of their health impacts ranging from mild discomfort up to long-term exposure cancer risk, depending on their type. VOCs are the main ingredient for making ground-level ozone, a major air pollution concern in many industrial countries and big metropolises. Ozone is formed when VOCs and nitrogen oxides (NOX) react in the atmosphere in the presence of sunlight. Exposure to ozone is considered harmful to humans, and has been attributed to respiratory infections and heart disease. Because of the negative health effects linked to VOCs and ozone, most develop strict abatement strategies and controls to limit the amount of VOCs released to the atmosphere.

VOC emissions result from both natural sources and human activities. Natural (biogenic) sources of VOCs include vegetation, forest fires, and even animals. Anthropogenic sources (human activities) include motor vehicles burning fuels, chemical manufacturing facilities, oil and gas industry operations, and are the main contributors to air quality problems. In general, the mobile sources make up the largest contributor to VOCs

followed by the oil and gas industry as well as other industries, such as manufacturers of paints and solvents. In the oil and gas industry, the major sources of VOC emissions come from bulk loading operations, storage tanks, and fugitive emissions. Saudi Aramco has been implementing a VOC Emissions Reduction Strategy in all its operations to protect the health and the environment.

## **Bulk Loading Operations**

Vapor emissions during the truck loading process at the bulk plants are emitted directly into the environment through a vent stack located above the loading bay canopy. Based on the recent Presidency of Meteorology and Environment (PME) regulations, facilities loading or unloading liquid hydrocarbons with a True Vapor Presence (TVP), greater than or equal to 1.5 pounds per square inch absolute (psia), in quantities greater than 75 m<sup>3</sup> per day, shall install a Vapor Control System (VCS) to control VOC emissions. In addition, the emissions into the atmosphere from the vapor collection system, due to the loading of liquid products into gasoline tank trucks, are not to exceed 35 milligrams of

total organic compounds per liter of gasoline loaded. The company has put tremendous efforts and investments in minimizing VOC emissions from its bulk plants, by ongoing installations of Vapor Recovery Systems (VRS).

## **Storage Tanks**

All floating roof Storage Tanks company-wide storing refined products with True Vapor Pressure between 1.5 to 11 psia are equipped with secondary seals. The Environmental Protection Department (EPD) monitors storage tanks on a continuous basis, to ensure the secondary seals are adequately installed to minimize VOC emissions.

## **Fugitive Emissions**

Fugitive emissions are mainly leakages to atmosphere from sources such as valve packing, compressor/pump seals, pressure relief devices and gasketed connections. Such sources are individually minor, but with tens of thousands of them in any major plant — the emissions can add up. In the VOC emissions reduction strategy, fugitive emissions have been taken into account and a structured Leak Detection and Repair protocol has

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been developed as well as deploying novel technologies such as the Solar Occultation Flux (SOF) technology.

### Leak Detection and Repair (LDAR) Program

LDAR is a work practice designed to identify leaks from components such as valves, flanges, pump seals, sampling connections, compressor, pressure relief valves, etc., so that emissions can be reduced through repairs at specified locations at regular intervals and within specified time frames.

The objective of the program is to comply with Saudi Arabia and Saudi Aramco Environmental fugitive emission regulations. Thus, LDAR Protocol has been developed by Saudi Aramco to guide all facilities on the effective implementation of the program.

The protocol reference is Method 21 of U.S. EPA 40 CFR Part 60. As per U.S. EPA Method 21 Current Work Practice (CWP), Flame Ionization Detector or Photo Ionization Detector shall be used to detect leaks from component quantitatively. This method requires monitoring each individual component in the plant using so-called sniffers, or detectors, to identify leakages. Moreover, Method 21 recommends using an Alternative Work Practice (AWP) to assist in conducting the LDAR. The recommended AWP calls for the use of a thermal imaging camera. The main objective of using such cameras concurrently with conventional LDAR is to identify leakages that are out of reach. These cameras typically use imaging technology that senses infrared radiation and therefore can identify the leak locations.

### The Solar Occultation Flux (SOF) Technology

SOF is a novel remote sensing

technology that is used to screen and quantify VOC emissions from industrial conglomerates, down to sub-areas in individual plants. It can measure olefins and alkanes but not aromatics. The SOF method has been applied in several larger campaigns in both Europe and the U.S. in more than 50 individual plant surveys over the last 7 years.

The SOF method utilizes the sun as the light source, and gas species that absorb in the infrared portion of the solar spectrum are measured, such as ethene, propene, alkanes and CO.

A mobile measurement platform, i.e., a truck, is used to circle around the emission sources. The measured data are combined with wind measurements to quantify the total amount of gas entering and leaving a certain industrial area. In more detail, the SOF measurements are conducted using an infrared spectrometer that is connected to a solar tracker, Figure 2.



Figure 1. Conventional LDAR detector component

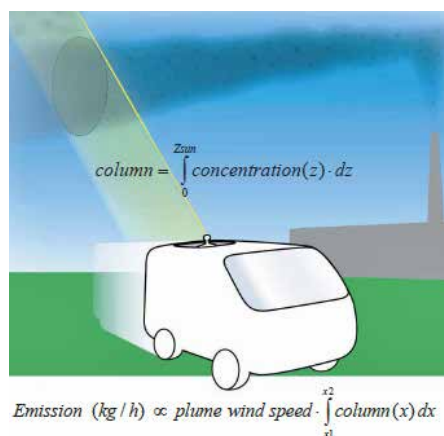


Figure 2. Typical VOC leak from a process



Figure 2. Solar Tracker. The solar tracker guides the sun light into the FTIR detector placed inside the white protective box. (Photo Source: FluxSense)

The latter is a telescope that tracks the sun and reflects the light into the spectrometer independent of its position. From the solar spectra it is possible to retrieve the path-integrated concentration (column) in the unit  $\text{mg}/\text{m}^2$  of various species between the sun and the spectrometer. The measurement system is built into a vehicle. To obtain the gas emission from a source, the vehicle is driven in such way that the detected solar light cuts through the emission, plume (Figure 3). To calculate the gas emission the wind direction and speed is also required, and these parameters are usually measured from high masts, towers and GPS balloon-borne sounding systems.



The SOF technology has been used in Saudi Aramco to survey several facilities in the Eastern Province to quantify VOC emissions and identify areas of improvement where mitigation measures are required. In addition, these measurements helped in improving the VOC emissions database used in the ozone reduction plan.

Saudi Aramco is continuing its efforts in reducing VOC emissions from its operations. Environmental Protection Department (EPD) plans to undertake a comprehensive survey and analysis of VOC emissions released from wastewater effluent systems company wide using novel tools approved by the U.S. EPA, i.e., TOXCHEM and WATER 9.

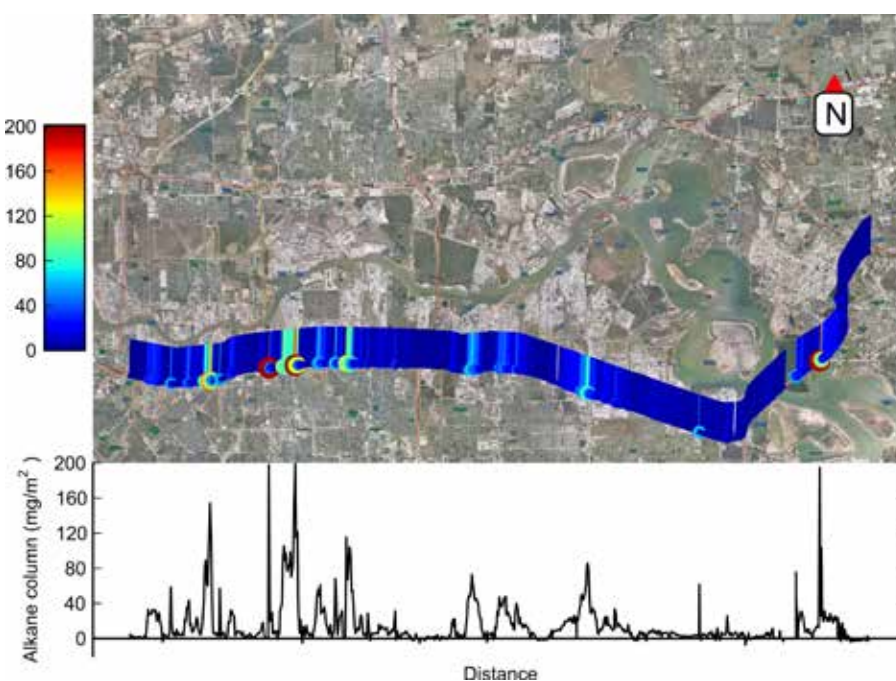
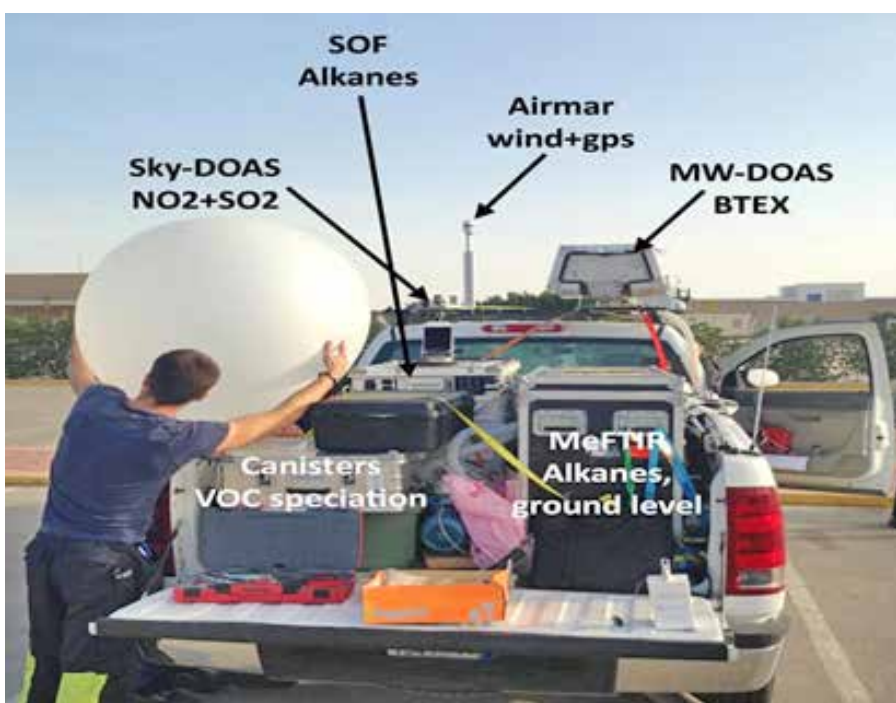


Figure 3. (Upper Left) The emission flux ( $\text{kg}/\text{h}$ ) is essentially achieved by driving downwind across the plume while integrating the measured atmospheric columns ( $\text{mg}/\text{m}^2$ ) of a particular gas and then multiply with the wind speed. (Upper Right) Instrument set up during the Saudi Aramco Survey in 2014. (Lower) Alkane SOF transect covering all of the Houston Ship Channel (HSC) performed on Sept. 25, 2006. Each measurement is indicated on the map with a circle and a line. The size and color of the circle indicates the magnitude of the alkane column measured, and the line indicates the direction the wind is blowing from. Below the map is a plot of the alkane column as a function of crosswind distance (used with courtesy to HARC – Houston Advanced Research Centre, project H53). (Photos Source: FluxSense)

# In Focus



# In Focus

## Saudi Aramco/KAUST Conduct Northern Red Sea Research Cruise

Scientists from the Environmental Protection Department participated in a Red Sea marine research cruise conducted by Saudi Aramco Marine Environment Research Center at KAUST (SAMERCK) in March of 2016. This research cruise took place in the northern Red Sea around Sanafir Island and Duba. Research performed during the cruise looked at several environmental parameters such as temperature, conductivity, pH, oxygen

the environmental impacts by future company operations in this area.

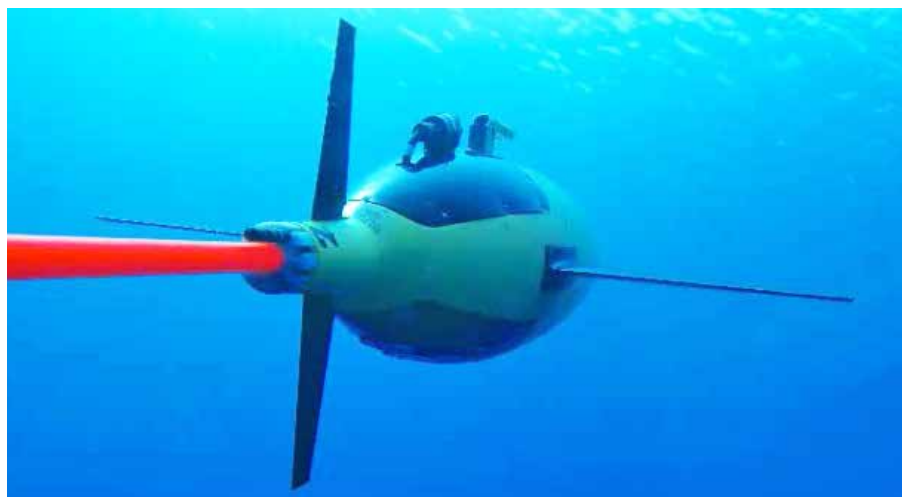
## Industrial Wastewater Treatment Champion (IWWC) Makes Glocal Tour

In support of the IWWC initiative, representatives from EPD and NBD conducted site visits to potential international joint venture partners' operation sites in South Korea, China and the U.S. The site visits focused on refineries and petrochemical industries and included water treatment, cooling water and steam supply, training

At press time, the identity of potential JV partners remained confidential.

## EPD, Renewables Department Mull New Technologies

As part of continuous efforts in providing assistance to the Renewables Department (RD), the Environmental Protection Department (EPD) has compiled and submitted technical specifications for a new Light Detection and Ranging (LIDAR) wind measurement system. The compiled technical specifications of the LIDAR were based on EPD's experience of using similar technology, recommendations from international organizations/institutes, and market benchmarking. The RD was requested to follow the same techniques in measuring wind speeds and directions for wind energy assessments campaigns in KSA. The objective includes the assessment of the wind energy potential in all Saudi Aramco areas and to facilitate the installation of future Wind Turbines. Wind LIDAR measurements are based on LASER technology to continuously measure wind speed and direction in various elevations, up to 200 meters and thus creating a continuous vertical wind profile.



A Saudi Aramco-KAUST expedition in the Red Sea relies on sea gliders to make continuous, long-term measurements of oceanographic parameters.

and turbidity. Sediment and water samples were also collected from various locations in the area to determine existing benthic biodiversity and seawater quality (heavy metals and hydrocarbon concentrations). Seagliders were also launched near Duba to make continuous, long-term measurements of oceanographic parameters. Data collected will increase our knowledge of the northern Red Sea, and it will be used to develop a baseline to quantify

and modeling, industrial wastewater treatment, produced water treatment, and oily sludge treatment facilities. The goal of this intensive one-week trip was to assess the technical capabilities and types of business models utilized by potential IWWC partners. The visit was extremely helpful in allowing Saudi Aramco to observe and understand the capabilities of the companies, which is crucial for the selection of the JV partner and moving to the next phase.

## EPD Completes First SHAHED Live-Streaming Webinar On Air Emission & Ambient Air Quality

As part of its 2016 awareness plans, the Environmental Protection Department successfully inaugurated a live-streaming webinar utilizing Saudi Aramco's SHAHED Video Streaming. This Webinar was conducted for Khurais Producing Department (KhPD) on March 29, 2016, during which EPD's Air Quality SMEs presented elaborative

## In Focus

details on Air Emissions Control and Ambient Air Quality. The presenters illustrated all relevant types of the air pollutants that affect atmosphere/human health, Saudi government PME regulations as well as Saudi Aramco regulations, standards and procedures to govern, control, and minimize air emissions. Overall, the webinar session was very well received and appreciated by the audience and the management of KhPD. Elsewhere, EPD is capitalizing on the transfer of technology and best practices from Industrial Hygiene experts by utilizing webinar technology. Industrial Hygiene Unit staff recently met with 3M technical support representatives to discuss the webinar topics that will be selected in the next three quarters. The topics selected include heat stress, confined space

These include innovative solutions for welding personal protective equipment, communication in high-noise areas and fit testing of hearing and eye protection, all of which aims to enhance safety, health and productivity.

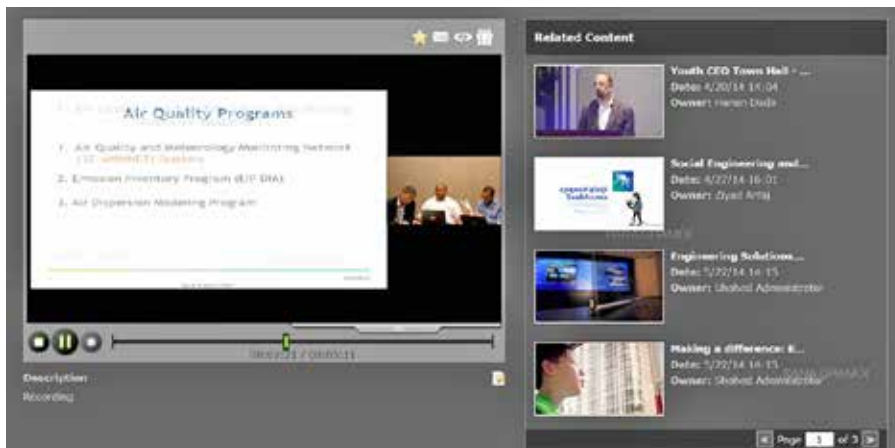
### PME Representatives Pay Visit to Saudi Aramco

Representatives from the Presidency of Meteorology and Environment (PME) visited Saudi Aramco in late March to analyze ways to reinforce synergies between the two organizations. The meeting's objective sought to strengthen the business relationships between Saudi Aramco and PME as well as encourage a shared vision of cooperation and understanding. Participants met to discuss mutual

### Saudi Aramco Attends Key Industry Meeting Analyzing Low Emissions Pathways

EPD representatives attended a three day workshop on Low Emissions Pathways organized by the IPIECA oil and gas environmental and social association in Houston. The workshop provided a unique opportunity for the global oil & gas industry to evaluate the implications of the new Paris agreement on climate change. In addition to the more than 200 representatives of IPIECA industry members in attendance, the workshop also welcomed speakers from various organizations, including but not limited to, the United Nations Environment Program (UNEP), the International Energy Agency (IEA), and automobile industry. The aim of the open-session workshop was to understand possible future scenarios regarding energy and technology and identify associated drivers, barriers and assumptions affecting the industry.

For example, IEA emphasized that to shift the energy sector toward a low-carbon path that supports economic growth and energy access, energy efficiency, renewables and Carbon Capture and Storage (CCS) are among key actions to be collectively addressed. Oil/gas reps also evaluated development and trends in the auto industry. Saudi Aramco's attendance was important to promote and expand industry adoption of petroleum friendly solutions such as CCS as a key enabling technology to meet the increasing demand for low emissions. Other venues include minimizing flaring, minimizing methane emissions and maximizing energy efficiency of oil and gas facilities. IPIECA discussions will be formalized in a consolidated outlook, which will be endorsed by IPIECA Excom in 2016 and distributed to member companies, as the industry perspective toward low emissions, laying out what the oil and gas industry needs to focus on during the coming years, to overcome



The Environmental Protection Department's live-streaming Webinar conducted for Khurais Producing Department (KhPD) covered Air Emissions Control and Ambient Air Quality.

entry, detection instruments for noise, respiratory protection, and lessons learned. Ways to enhance the webinar sessions were considered, including onsite participation to prevent technical difficulties. The topics selected will focus on Industrial Health programs and their applications to the oil and gas industry. Technical support in Industrial health instrumentation innovation and new technologies were also discussed.

environmental concerns and matters with Saudi Aramco's Environmental Protection Department. During the meeting several environmental issues and concerns were discussed, and all parties agreed on the need to improve existing relationships as well as enhance joint practices and interactions, to enrich the Kingdom's environmental protection efforts. The visit concluded with visits to both R&DC and OSPAS.



the challenges the world faces in transitioning to a low-emission future. EPD also attended the Annual General Meeting and the IPIECA Executive Committee meeting, which reviewed the 2016/2018 business plan.

### Saudi Aramco Hosts Water Conservation Campaign at Dhahran Mall

The Environmental Protection Department and the Public Relations Department partnered to organize an awareness campaign for water conservation at Dhahran Mall from March 20-26 in celebration of the World Water Day. The campaign targeted families and youngsters and utilized 4-D multimedia technology to convey awareness messages. The campaign's objectives sought to enhance public awareness of water importance, water scarcity, water resources and positive behaviors to conserve water during daily activities. Separately, Saudi Aramco representatives participated in another water conservation campaign in Alhsa Mall. Technical support and knowledge sharing regarding water in general and water conservation in particular were provided during the one-week event.



Engaging visual displays help spread awareness over the need to conserve water (Photo Source: Saudi Aramco)



The Mall of Dhahran was the site of a Saudi Aramco water conservation awareness campaign that targeted people of all ages with 4-D multimedia technology. (Source: Saudi Aramco)

The campaign's objectives sought to enhance public behavior regarding water use and to trigger changes in the way water is perceived, by sharing facts related to freshwater resources concerns in the Kingdom. Water conservation tools/kits provided by the Water Ministry were distributed to the attendees.

### Sinopec HSE Delegation Visits Saudi Aramco

Eight members from Chinese petroleum company SINOPEC's HSE management visited Saudi Aramco on March 3, 2016, to share best practices and gain exposure to company programs in safety and environmental protection. The delegation was hosted in Al Midra building by EPD Manager Osama Fageeha. The visit featured presentations delivered by subject matter experts from EPD, Loss Prevention Department and Johns Hopkins Aramco Healthcare on industrial hygiene, hydrogen sulfide protection, risk management, change management, behavior-based

safety, contractor management, HSE supervision, etc. The visit ended with a tour of the Upstream Professional Development Center (UPDC), where SINOPEC guests were given an overview of various programs including the drilling simulator and the four-sided cave applications followed by a presentation on the Upstream Behavior Based Safety System.

### Saudi Aramco Participates At Fifty-First Session Of The Intergovernmental Panel On Climate Change (IPCC) Bureau

As part of the Saudi Arabian governmental team, EPD recently attended the 51st session of the IPCC Bureau, which serves as a preparatory meeting to the 43rd session of the IPCC. The Bureau discussed the implications of a number of decisions and recommendations related the outcomes of COP-21 Paris agreement, especially the IPCC mandate to provide a special report in 2018 on the impact of global warming of 1.5°C above



Muhammad Irfan Tariq, Pakistan, speaks with EPD's Abdullah K. Tawlah, Saudi Arabia, at the 51st session of the IPCC Bureau. (Photo Source: Saudi Aramco)

pre-industrial levels and related global greenhouse gas emission pathways. The outcome of this study is of great significance, as it will determine the scientific context to the Paris Agreement's aspirational goal, and other related discussions, such as the "carbon budget" and "stranded assets." EPD will continue its efforts to ensure that Saudi Arabia's interests

remain appropriately reflected in global climate change venues.

### **Saudi Aramco Participates In Japanese Tour On Low Carbon Technology**

At the invitation of the Japanese Ministry of Economy, Trade and Industry (METI), EPD and R&DC participated

in a low-carbon technology tour in Japan. The program took place Feb. 22-26, 2016. The tour's main objective sought to enhance capacity building on low-carbon technology, such as Carbon Capture and Storage (CCS) and its utilizations. The program consisted of site visits to CCS locales, research and development centers and an overview of Mitsubishi Heavy Industry (MHI) manufacturing facilities. Dialogue and technical discussions with different companies and government representatives regarding CCS and energy also took place. Discussions highlighted CCS and its potential to curb CO<sub>2</sub> emissions and to enhance oil recovery. CCS enjoys high priority in well-established Japanese research centers, thanks to significant progress made in recent years. The tour unveiled CCS collaboration opportunities between Saudi Aramco and Japanese companies, in terms of technology implementation, utilization, and innovation.

### **World Bank Members Visit Saudi Aramco, Discuss Flaring**

Representatives from the World Bank visited Saudi Aramco as part of a regional tour aimed at attracting more governments and oil companies to join its Zero Routine Flaring by 2030 initiative (ZRF). The meeting was attended by the CTO, ES Executive Director, EPD Manager, Technology S&P Department Manager and other company representatives. A general overview of Saudi Aramco's environmental protection strategy and efforts was presented to World Bank delegates followed by a visit to the Engineering Solution Center hosted by P&CSD, who provided an overview of the company's Corporate Flare Monitoring System (CFMS) and flare minimization strategies. World



Members from Chinese petroleum company SINOPEC's HSE management visited Saudi Aramco to share best practices and knowledge (Photo Source: Saudi Aramco).



Representatives from the World Bank, a multilateral development institution, visited Saudi Aramco recently to learn more about the company's methods to cut flaring. (Image source: The World Bank Group).

Bank delegates were impressed by the company's pioneering efforts in environmental protection and flare minimization, commending Saudi Aramco for its leadership and invited the company to join its initiative. Saudi Aramco indicated that through previous discussions, World Bank and Saudi Aramco definitions of safety, as well as non-routine flaring are generally compatible. Saudi Aramco expressed concerns with the World Bank's current definition of routine flaring, which includes emissions from many sources, such as hydrocarbon storage tanks, cogeneration units, tail gas treatment units, heaters/boilers, etc., language with which the company may disagree.

Company representatives indicated that joining ZRF initiative will be considered after resolving differences regarding routine flaring definitions.

### EPD Hosts Integrated Pest Management Training For Government Entities

In line with environmental excellence and building local capacity, EPD provided three certified Integrated Pest Management (IPM) training sessions to more than 50 participants from various government entities involved in pest control, including the Eastern Province Mayorality, the Ministry of Health, the Ministry of Agriculture, the Ministry of Water and Electricity and King Abdulaziz Port. The UK Chartered Institute of Environmental Health (CIEH) has endorsed the course, which is the first offering of its kind in the region. Training covered topics such as the public health significance of pests, pest classification and biology, inspection and monitoring, pesticides, and the implementation of IPM.

### Saudi Aramco Leads Middle East NORM And Natural Radiation Management Conference

In recognition of Saudi Aramco's leadership in the area of managing Naturally Occurring Radioactive Materials (NORM), EPD was invited to chair the NORM and Natural Radiation Management Middle East 2016 conference held in Abu Dhabi in January of 2016. In addition, two EPD subject matter experts led panel discussions in the areas of NORM regulatory standards and health protection for radiation workers. The event welcomed a wide range of international participants including representation from guidance and regulatory bodies such as the International Commission on Radiological Protection (ICRP) and UAE Federal Authority as well as national and international oil companies and radiation service providers. Key areas of focus included NORM handling, treatment and disposal, regulatory control and establishing common standards across the industry and in particular the GCC.



Participants of an EPD-led course on pest control for the public sector take time out for a group photo during their training. (Photo Source: Saudi Aramco)

## Schedule of Upcoming Events

| Date                             | Event Title  | Location           |
|----------------------------------|--|--------------------|
| September 27-<br>October 7, 2016 | ICAO 39th Triennial Assembly   | Montreal, Canada   |
| September 19-23                  | IMO Marine Environment Protection Committee 70th Session                 | London             |
| October 24-25, 2016              | International Conference on Environmental Health & Safety                | Valencia, Spain    |
| October (Date TBD)               | SAEEP Train the Trainer Session  | Jedddah            |
| November 3, 2016                 | Environmental Coordinators Workshop                                      | Dhahran            |
| November 7-8, 2016               | IPIECA Extraordinary general meeting                                     | Dhahran            |
| November 7-18, 2016              | The 22nd session of the Conference of the Parties (COP 22) to the UNFCCC | Marrakesh, Morocco |
| December 7-8, 2016               | Environmental Stewardship Workshop                                       | Dhahran            |
| February 27, 2017                | The Global Food Safety Conference  | Houston, Texas     |

Note: EPD does not guarantee accuracy of this schedule, as events and times are prone to changes and/or cancellation.

# Enviro Snaps





# Enviro Snaps

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## Hoopoe, the bird of wisdom

We've all seen the Hoopoe (*Upupa epops*) around us, especially these days during their seasonal migration. Perhaps most don't know that the Hoopoe migrates from its breeding grounds across Europe and Asia through Saudi Arabia to central and southern Africa, a journey of several thousand kilometers, which is pretty incredible for a 60-g bird. This bird is colorful and noted for its distinctive "crown" of feathers. The Hoopoe is the

only extant species in the family Upupidae. Its diet is mostly composed of insects, though it may include small reptiles, frogs and plant matter such as seeds. It is a solitary forager that typically feeds on the ground. Hoopoes have been mentioned in the Quran. The story of the Prophet Solomon and the "Hudhud" is well known, and it became known in Arabic culture and folklore as the symbol of wisdom.

-Abdullah Alsuhaibany



