

Issue No. 33 - 2023



Enviro News

Environmental Protection



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Enviro news is a publication that promotes environment protection by raising awareness of matters related to environmental sustainability and health through the lens of Environmental Protection organization at Aramco.

This edition brings you a range of articles on Saudi Aramco's efforts to protect biodiversity, to ensure public health and to advocate the company long-term sustainable development ideals. The articles were clustered along the relevant themes of the Sustainable Development Goals with relevant, current and informative content.

It is our great pleasure to have you with us and we hope you enjoy this edition of Enviro News.

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A message from Fathi Al-Saleem

Vice President of Environmental Protection



The Sustainable Development Goals Report 2023 provides a global overview of progress on the implementation of the 2030 Agenda for Sustainable Development, using the latest available data and estimates. It tracks the global and regional progress toward the 17 goals with in-depth analyses of selected indicators for each goal.

According to the report, interlinked crises are putting the 2030 Agenda for Sustainable Development in grave danger, along with humanity's very own survival. The report highlights the severity and magnitude of the challenges before us. The confluence of crises, dominated by COVID-19, climate change, and conflicts, are creating spin-off impact on food and nutrition, health, education, the environment, peace and security, and affecting all the Sustainable Development Goals (SDGs). The report details the reversal of years of progress in eradicating poverty and hunger, improving health and education, providing basic services, and much more. It also points out areas that need urgent action in order to rescue the SDGs and deliver meaningful progress for people and the planet by 2030.



PEOPLE

Alignment of Environment Protection efforts with the Sustainable Development Goals (SDGs)



Maan M. Iskander

DIRECTOR, Green Energy & Environmental Policy Department

“Our environmental sustainability initiatives are geared towards UN Sustainable Development Goals and the Kingdom’s Vision 2030.”



Humoud W. AlUtaibi

DIRECTOR, Environmental Protection Department

“Our environmental and health performance is aligned with ambitious targets while strategically embedding Circular Economy Ideals.”

Context and Relationship to SDGs

The High-Level Political Forum (HLPF) is the central UN platform for the follow-up and review of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) at the global level. The theme for 2023 was “Accelerating the recovery from the coronavirus disease (COVID-19) and the full implementation of the 2030 Agenda for Sustainable Development at all levels.” The HLPF also reviewed other SDGs including SDG 7 (affordable and clean energy) and SDG 17 (partnerships for the goals).

The HLPF is open to Major Groups and other Stakeholders at the international level, including the “Business & Industry” Major Group through which Environmental Protection (EP) represented Aramco. At the HLPF, EP was able to share its views on the SDGs and relevant Aramco SDGs related activities aimed at accelerating efforts toward attaining the 2030 Agenda.

Tracking of SDG 7 “Affordable and Clean Energy”

A 2023 report “Tracking SDG7: The energy progress report 2023” tracks global progress toward SDG 7: Achieving affordable, reliable, sustainable and modern energy for all. In summary, the report highlights the following:

- Current efforts are inadequate to enable the world achieve SDG 7 by 2030.
- Among the major economic factors impeding the realization of SDG 7 globally are the uncertain macroeconomic outlook, high levels of inflation, currency fluctuations, debt distress in a growing number of countries, lack of financing, supply chain bottlenecks, and tighter fiscal circumstances.
- The effects of the COVID-19 pandemic and uncertainty in global commodity prices are expected to impact the rate of progress, particularly in the most vulnerable countries and those that were already lagging behind.

EP is of the view that significantly more efforts must be done towards energy management practices around the world, including matters related to environmental protection and sustainability. What the “Tracking SDG7” report demonstrates is that more needs to be done by various stakeholders in the energy value chain to ensure greater access

to affordable and clean energy with no harm to the environment. The range of EP’s initiatives and research efforts are encapsulated within the elements of the Circular Carbon Economy (CCE) framework which is strongly aligned with the SDGs. The following elements of the CCE framework were shared with delegates and observers at the HLPF to assist in advancing global SDG capacity building efforts.

Circular Carbon Economy (CCE) – Definitions and Efforts

Commonly used definitions

- **Reduce:** Lowering emissions through energy efficiency, renewables (including bioenergy and e-fuels) and nuclear energy.
- **Reuse:** Converting emissions into industrial feedstock, including via emissions to value and carbon recycling.
- **Recycle:** Neutralizing emissions through natural processes and decomposition, including biofuels, bioenergy, and energy carriers, including methanol, ammonia, and urea.
- **Remove:** Removing atmospheric emissions through natural and geological means and direct air capture.
- **Crosscutting:** Using hydrogen, modern bioenergy and biofuels and energy infrastructures.

Reduce efforts

In October 2021, Aramco announced its ambition to achieve net-zero Scope 1 and 2 GHG emissions across wholly-owned operated assets by 2050. This will be achieved through a number of areas, including:

- Investments in low-emission technologies.
- Deployment of energy efficiency programs.
- Investment in renewable energy.

Energy efficiency efforts

Aramco seeks to reduce energy consumption at facilities, designs new facilities to be energy efficient, and promotes energy efficiency within its areas of influence. While our reporting boundary expanded in **2022**, at a company in-Kingdom level, the energy intensity was **112.9** thousand Btu/boe (a reduction of **3%** from the prior year), demonstrating continued improvement in our energy efficiency initiatives across our business. We started an energy efficiency management program in **2000**. The program has evolved through the implementation of energy efficiency initiatives such as process improvements, fuel gas optimization, higher co-generation utilization, continuous performance monitoring of significant energy users, reduction in energy for crude oil transportation, and load management of top energy users.

Moving forward, several initiatives have been planned to improve energy efficiency, including:

- Upgrading of simple cycle gas turbines with energy efficient combined cycle systems.
- Replacement of older inefficient boilers with highly efficient fast ramp up boilers.
- Implementation of advanced digital solutions to improve energy efficiency performance.



At the end of 2022, all our operational facilities received the ISO 50001 certification for their energy management system. It enables our facilities to focus on an ongoing, sustained improvement in energy efficiency, and reduction in greenhouse gas emissions, along with monetary savings as a result of smarter energy utilization and improved energy efficiency.

Methane efforts

Aramco’s efforts in reducing methane emissions from our operations are tangible and pragmatic — we are building resilience in the energy infrastructure that ensures our industry’s ability to support global economic growth and provide clean and affordable energy.

Over the last five decades, Aramco has invested heavily in building infrastructure, such as its oil and gas plants. They are part of the Master Gas System (MGS) that utilizes the Kingdom's vast natural resources in an environmentally responsible manner. The MGS was developed in the early 1980s and achieved significant reduction in our methane emissions while creating additional value for the Kingdom from the recovered gas.

Since 1980, we have been recovering associated flared gas, resulting in significant carbon dioxide and methane emission avoidances. We have reduced our flaring volumes considerably since the mid-1970s to near Zero Routine Flaring. By installing flare gas recovery systems, we have achieved a flaring intensity lower than 1%. Our flaring activity is monitored in real-time from our Fourth Industrial Revolution Center in our Dhahran headquarters to track our flaring intensity performance. Today, our flaring intensity is among the best in the world, and we are committed to sharing our best practices and knowledge with peer companies.

In 2018, Aramco implemented a voluntary comprehensive leak detection and repair program, enabling reductions in emissions through the identification and mitigation of fugitive leaks, one of the largest sources of methane emissions in the oil and gas industry. The program is designed to systematically identify and repair leaking equipment and components, such as valves, flanges, connectors, pumps, compressors and tanks across all operating facilities in Saudi Arabia. Aramco's current upstream methane intensity is 0.05%, which is among the lowest in the oil and gas industry, and is aligned with our corporate commitment to the Oil & Gas Climate Initiative's Aiming for Near Zero Methane initiative.

Petroleum-based ZEV efforts

Aramco is currently exploring a demonstration of innovative Zero Emissions Vehicles that combine petroleum based low-carbon fuels with onboard carbon capture processes to provide a petroleum based zero-carbon alternative for existing internal combustion engines. The ZEV infrastructure will support decarbonization efforts by providing an alternative that utilizes the existing infrastructure in most countries. The reduction of emissions will be achieved through the use of low-carbon drop-in petroleum-based fuels, and carbon capture using advanced materials. Research shows potential reductions of tailpipe emissions from implementing this technology combination.

We have already completed the first part related to the petroleum-based fuel blends and confirmed the reduction benefits accordingly. We are currently working on the carbon capture component by running a demonstration followed by a detailed material development phase to further tailor materials for maximum capture.

EP Directors forward looking aspirations: the road toward the 2030 Agenda (SDGs)

The HLPF continues to provide leadership, guidance and recommendations for the implementation, review and monitoring of the SDG agenda in a principled and integrated framework. The 2023 HLPF was enriched with significant insights from various stakeholder groups, in a way that suggests future partnerships to achieve common energy goals is possible and within reach. At EP, we will continue to promote the protection of our environment and people for a sustainable energy future through:

- Robust environmental and health regulatory compliance across our operations.
- Enhancement of environmental and health performance impactful solutions.
- Driving scalable circular solutions as part of our innovative and practical efforts.
- Advancing the company's stated ambition in achieving net-zero emissions by 2050.
- Achieving net positive impact on biodiversity and eco-system services across our operations.
- Spearheading the implementation of nature-based solutions through cutting-edge technologies.
- Advocating for environmental protection and sustainability through elevated stakeholder engagement avenues, building capacity and promoting best practices across the industry.

Collectively, we will continue to evaluate emerging challenges and opportunities in the context of the 2030 Agenda for Sustainable Development; unlocking new, innovative and realistic solutions while turning strategic goals into concrete results for the benefit of all.

Sustainable Development and the Oil and Gas Industry

**By Hassan M. Alzain & Victor R. Kalimugogo,
Green Energy and Environmental Policy Department**

Introduction

The primary forum for the United Nations to bring parties together with world leaders, scientific experts, and civil society members is the "Conference of the Parties" ("COP") to the United Nations' Framework Convention on Climate Change (UNFCCC). The COP is the supreme decision-making body of the UNFCCC, which is itself an international treaty to address climate change. With the exception of 2020, the COPs have convened every year since 1995 to identify and assess key climate issues. They also assess progress toward the goals of the Convention and establish and enable an internationally agreed framework to support the delivery of the goals (UN, n.d.). As the need for climate measures has grown more urgent, recent COPs have become correspondingly higher in profile, attracting intense comment and debate, as well as often tense negotiation between the countries involved (Aberg et al., 2022).

COP27 (Figure 1) was held in November 2022 in Sharm el Sheikh, Egypt, and focused on four key themes: mitigation, adaptation, finance, and collaboration. Mitigation refers to the core task of limiting and stabilizing the rise heat-trapping greenhouse gases (GHGs) in order to maintain average temperature increases to 1.5 °C. Collaboration refers to the efforts to build an international consensus and regulatory structure to achieve the goals of mitigation efforts. For the purposes of this paper, however, the two most important themes are adaptation and finance.



Figure 1: COP27, Sharm el Sheikh (Egypt)

Adaptation

Adaptation is the task of adjusting to actual or expected future climate conditions in order to reduce risks to humans from the harmful effects of climate change (such as physical risks like sea-level rise and more intense extreme weather events, transition risks such that follow any socio-economic movements toward low-carbon futures). Adaptation also refers to efforts to exploit any potential beneficial opportunities associated with climate change (for example, longer growing seasons or increased yields in some regions) (NASA, n.d.; Fisher, Dicker and Kyriacou, 2021).

Finance

Finance refers, in general, to the need to develop mechanisms to support the funding of climate change measures (and especially in that regard adaptation measures). In the context of recent COPs, it refers to the process of agreeing “loss and damage” compensation and adaptation support to developing countries who are most vulnerable to the negative impact of climate change but historically least responsible for causing that change (Byrnes and Surminski, 2019; Stuart-Watt, 2022). Figure 2 presents an illustrative framework of global efforts to address loss and damage from climate change.

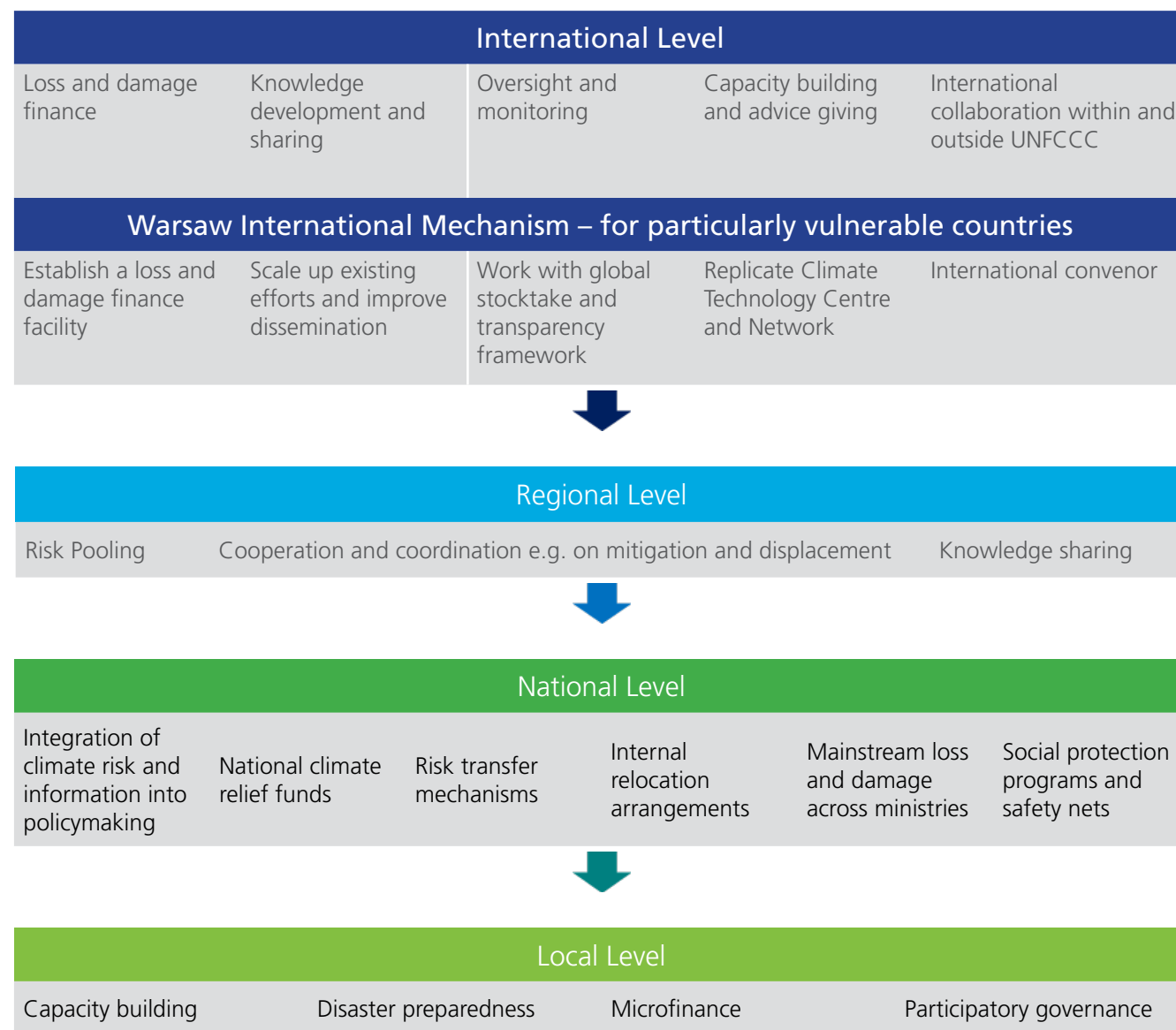


Figure 2 Loss and damage framework (Byrnes and Surminski, 2019)

Sustainable Development Goals

The United Nations (UN) Sustainable Development Goals (SDGs) were established in 2015 as successors to the erstwhile Millennium Development Goals (MDGs) with the aim of creating “a world free of poverty, hunger, disease and want, where all life can thrive,” (UN, 2015). The 17 goals are focused on ending poverty and reducing inequality, which is understood broadly to encompass health, gender, and economic inequalities between countries and within countries. To support those broad ends the goals also target issues like access to education, water and sanitation, food security, and sustainable work and industry (UN, 2015). Each of the goals is supported by a number of specific targets that countries are expected to work toward (169 targets in all). A key difference between the previous MDGs and the current SDGs is the limitation in scope of the MDGs, which focuses on the challenges facing the poorest in the poorest countries, and were predicated on financial and other support from rich countries to poor countries. The MDGs were, in essence, intending to make an impact on the worst effects of poverty. The SDGs have a wider scope. Not only do they cover more areas, indeed in a sense all aspects of life on Earth, but they are envisaged as applying to all nations, rich and poor. They represent a shift in focus from development as targeted only on the poorest, to development as a reduction of inequality in general.



Figure 3: The sustainable development goals (UN, 2015)

Interface Between Climate Change and Sustainable Development

The question can be asked, how does the climate agenda as championed by the UNFCCC interact with the sustainable development ideals of the SDGs? On one level, the SDGs directly target climate action (Goal 13), Life below water (Goal 14) and Life on land (Goal 15) which can be directly linked to the effects of climate change. On another level, however, we can see that the COP process has become concerned with the potential loss and damage arising from climate change, and the need for (1) financial support frameworks to help developing countries mitigate that loss and damage; and (2) broad adaptation of society to live with the effects of climate change. These concerns profoundly interact with the SDGs and this interaction was recognized in the Paris Agreement that underpins global action on climate change, in so far as the goal on adaptation directly references sustainable development:

“to enhance adaptive capacity and resilience; to reduce vulnerability, with a view to contributing to sustainable development; and ensuring an adequate adaptation response in the context of the goal of holding average global warming well below 2°C and pursuing efforts to hold it below 1.5°C.”

Clearly the SDGs to eliminate poverty and hunger, ensure access to clean water and sanitation, and protect life on land and at sea, are profoundly dependent on mitigating and adapting to the loss and damage of climate change since it is precisely in those areas that the loss and damage will be most directly felt (Iberdrola, 2023). In addition, however, it is widely recognized that the SDGs as a whole are interlinked with action on climate change. All the goals are potentially compromised in so far as the effects (loss and damage) of climate change represent a significant headwind reinforcing inequality – both between nations in so far as climate change impact are expected to fall most heavily on the poorest countries, and within nations in so far as efforts to tackle inequalities in gender, health and education (among others) risk being set back if countries have not taken steps to adapt to the effects of climate change. In short, failure of the adaptation pathway in COP will almost inevitably go hand in hand with failure of the SDGs.

Conversely, successful adaptation supported by an effective loss and damage financing framework, offers significant positive opportunities to the world’s developing countries to boost efforts to reduce inequalities in line with the SDGs. For example, there are opportunities to reduce poverty and simultaneously build climate resilience, including reducing water usage in sustainable and equitable ways, adapting farming practices to mitigate loss of farming land due to climate change while also taking advantage of new farming opportunities arising from change. Beyond this, there are also opportunities for developing countries to build sustainable infrastructure and industries that can generate significant new sources of

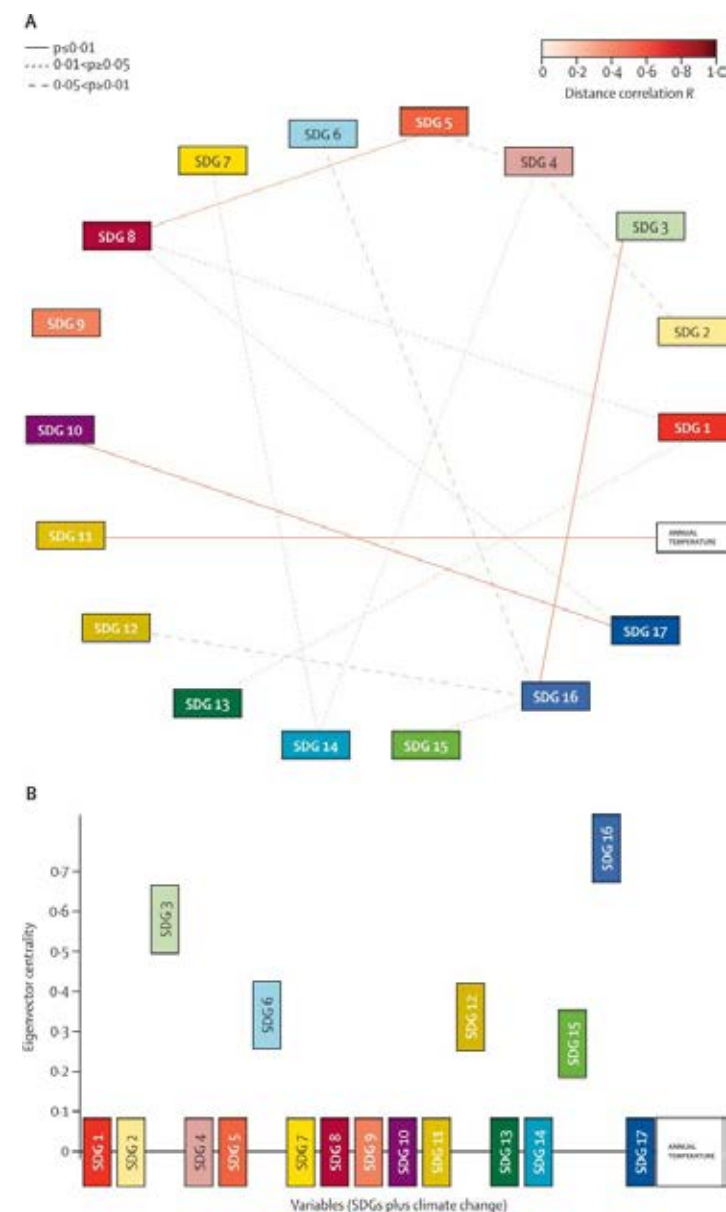


Figure 4: The network of SDGs and climate change (A) and normalized eigenvector centralities (B) for the country grouping Emerging Markets (Source: Laumann et al., 2022)

income that can in turn be utilized to support the resourcing of health, education, and other SDG goals. As an example, solar power is becoming a growing source of clean energy for developing countries and a source of foreign currency income. Many of these countries have not been endowed with sources of hydrocarbon energy so the ready availability of solar is important to them.

The above discussion merely scratches the surface of the interlinkages between the SDGs and climate action. Laumann et al set out a detailed evaluation in a fascinating recent paper providing a network analysis of how the interlinkages between the SDGs and climate change play out across different country groupings (Laumann et al., 2022). An example of their network analysis is provided in Figure 4.

COP 28 Forward Looking Expectations

The 2023 UN Climate Change Conference (COP28) will convene from 30 November to 12 December 2023 in Dubai, United Arab Emirates (UAE). COP28 (Figure 5) will be a defining moment and the UAE will be expected to lead efforts to find realistic, practical, and pragmatic solutions to accelerate the global climate solutions. Key actions include:

- The first formal assessment of countries’ progress toward the Paris Agreement’s target to limit climate change (“first global stocktake”) will conclude at COP28. Each stocktake is a two-year process that happens every five years, with the aim of assessing global collective progress toward achieving its climate goals. The first global stocktake takes place at the mid-point in the implementation of the 2030 Agenda for Sustainable Development and its SDGs, including Goal 13 (climate action).
- The need for global adaptation has become clear, but is still significantly short of hundreds of billions of funding. The transitional committee set up at COP27 for the Loss and Damage Agreement (agreement to help low-income countries that are facing the effects of climate change) will be making recommendations on how to operationalize the fund at COP28.



Figure 5: COP28, Dubai (UAE) Theme “UNITE. ACT. DELIVER.”

Implications for the Oil and Gas Industry

This paper does not directly address efforts by various stakeholders to phase out fossil fuels. What is clear is that a low-carbon future is on the agenda for governments, business, and civil society. The interesting question for now is how the oil and gas industry, in its current structure, can play a role in recognizing and supporting the interlinkages between the SDGs and climate action that have been previewed in this discussion. The industry will have a role as a result of increasingly assertive corporate social responsibility expectations of stakeholders; what remains unclear is what this role will be. These expectations are now being underpinned by more stringent regulatory requirements for larger organizations in respect to sustainability reporting. Thus, the CDP, an international non-profit organization, which sets a framework through which over 20,000 large companies report their sustainability efforts, has linked with the International Sustainability Standards Board (ISSB) to create a new more comprehensive reporting framework for 2023 onwards, and this is expected to become the minimum regulatory expectation in many countries (Obienu, 2022).

In essence, the oil and gas industry is being increasingly required to engage with sustainability issues. In light of this development, it is clear that direct corporate support for the SDGs will become an important avenue for the industry to explore. Just as the SDGs are predicated on a global partnership of all stakeholders, COP27 issued a call for non-party stakeholders to engage more with climate action (COP27, 2022). In that light, the industry needs to redouble efforts to demonstrate its engagement on the one hand with each of the seventeen SDGs and, on the other hand, with the COP themes of supporting communities (i.e. not just the industry itself) to adapt to climate change. This may well also entail financial support to communities likely to experience loss and damage as a result of climate change.

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Humble adventures of a circular economy journeyer

By Abdulaziz Sharaf,
Environmental Protection Department

Swiss Family Robinson

A story of trials, survival, and flourishing. "Swiss Family Robinson" is a famous book that tells the story of a Swiss family that is shipwrecked on a journey and manages to find a way to the shores of a new, strange land. On this strange land, the family needs to adapt, improvise and work with nature in order to survive. Not only does it survive, it ultimately learns to thrive in the new life.

Circular Economy

The story of the circular economy follows a similar path. The circular economy is the "Swiss Family Robinson" of modern living that will enable us to align socio-economic systems with natural systems. In a strange twist of fate, the circular economy story also has Swiss roots. The founder of the concept is an architect from Switzerland, Walter Stahel. Stories worth sharing includes the following:

Opening lines – shipwrecked: the modern economic system annually extracts billions of tons of biomass, fossil fuels, metal ores, non-metallic minerals and other natural resources. The impact of modern humans is so significant that it now has a geological name: the Anthropocene epoch. Unsustainable consumption and production practices cause an increasing environmental and socio-economic impact such as loss of biodiversity, climate change impact (like increasing surface temperatures) and various health problems associated with pollution. Additionally, global population growth is going to exacerbate this impact, especially as the "Global South" aims for its own economic development.

Surveying the landscape – let us define the circular economy: the circular economy is an economic model of production and consumption that seeks to reduce waste, recover resources at the end of products' lives and divert them back into the economic cycle, thereby reducing ongoing pressure on the environment. This is in contrast to the linear economy model which we are all a part of: extract,



Figure 6: Two Versions of Our Planet



produce, use, and dispose. It is of utmost importance to shift our practices from the linear “Materials Economy” model and adapt to a more circular model. In fact, the Kingdom has already started to promote circularity to target a sustainable future over the coming decades. Similarly, Aramco has embarked on a circularity campaign that seeks to reduce emissions, minimize waste generation, conserve water resources, enhance biodiversity and single consumption models.

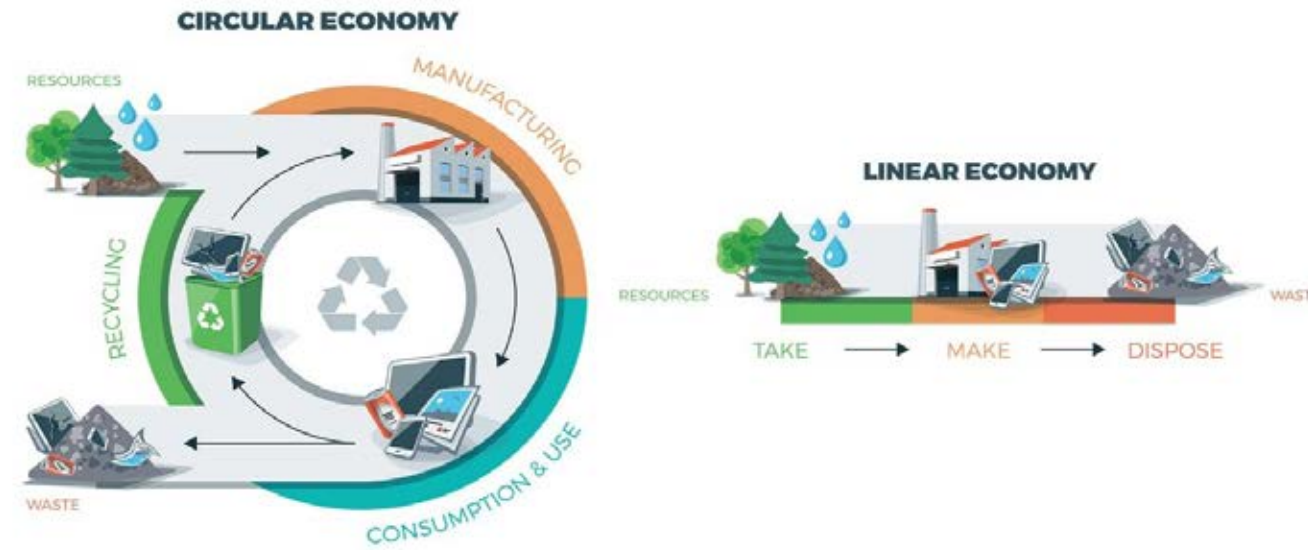


Figure 7: Linear Economy vs. Circular Economy

Thriving in a “strange new land” - a series of innovations: Let us consider the start of my career in 2018 in Hawiyah Natural Gas Liquid Recovery Plant as a process engineer in the CO₂ Compression Facility where I was involved in the carbon dioxide (CO₂) capture and reinjection project for enhanced oil recovery. The plant receives the separated CO₂ from sour gas and injects it into the Ghawar Oil field in Uthmaniyah Gas Oil Separation Plant (GOSP-7) through several processes of separation, dehydration, and compression. This model eliminates Greenhouse Gas (GHG) emissions by reinjecting 800,000 tons of CO₂ each year. It is a one-of-a-kind project that falls under the umbrella of the Circular Carbon Economy, which is an extension of the circular economy concept that prioritizes carbon emissions and energy while retaining the material, energy, water, and economic flows of the circular economy. It aims to reduce GHG emissions, and is therefore an important direction in the company’s vision toward decarbonization.



Figure 8: FGP Moving Bed Biofilm Reactor

Fast forward to 2020, when I transferred to Fadhili Gas Plant Department (FGPD). At

FGPD I was the commissioning leader of the first-of-its kind industrial Wastewater Treatment Plant (WWTP). The WWTP receives stripped wastewater from the gas wells and treats it through several processes of physical separation, chemical and biological treatment, and filtration. The innovative application of the WWTP is the unique biological treatment at the Moving Bed Biofilm Reactor (MBBR), which oxidizes the dissolved organic carbon compounds using microbes (i.e., bacteria) to treat the wastewater. The treated water is then routed to FGP’s three cooling towers as water makeup. This state-of-the-art facility aims to recycle and produce 200 MM gallons of water annually; it is a remarkable story of innovative practices targeted towards natural conservation.

Reflections: The story of the Robinson family is about more than just innovations and adaptations to a new life. It is a story about social relations, values and a desire to live in harmony with systems around us. As the family adapted to the new island, they prayed regularly to express thanks for their survival. The parents also passed down lessons to their sons for the future.

Likewise, I hope my humble stories can shed a light to you about the benefits of shifting from a linear to a circular mindset. We have to redesign our economic model and structure from a linear “throwaway” culture to a circular efficient culture. The company has created a strong enabling environment in this regard, it has provided several certification programs on the circular economy and sustainability for all employees to apply in their fields of work. Aramco established seven focus areas in order to pave the transition to a more circular business model. It has even established seven focus areas to pave the way for the transition to a more circular model. This framework should assist you as an Aramco professional to begin your circularity journey, engage with relevant stakeholders in your sphere of influence and think about your own personal contributions to the current and future economic models.



Figure 9: Recycle Waste for a Better Tomorrow



Figure 10: Working for a Sustainable Future

As one of the world’s leading companies, Aramco can lead the way in embracing circularity of economic models and steer the ship of humanity toward a safer course. There is no better time to make discoveries, adapt and pass lessons down to our future discoverers and innovators. Just like the famous Swiss Family did a few centuries ago.

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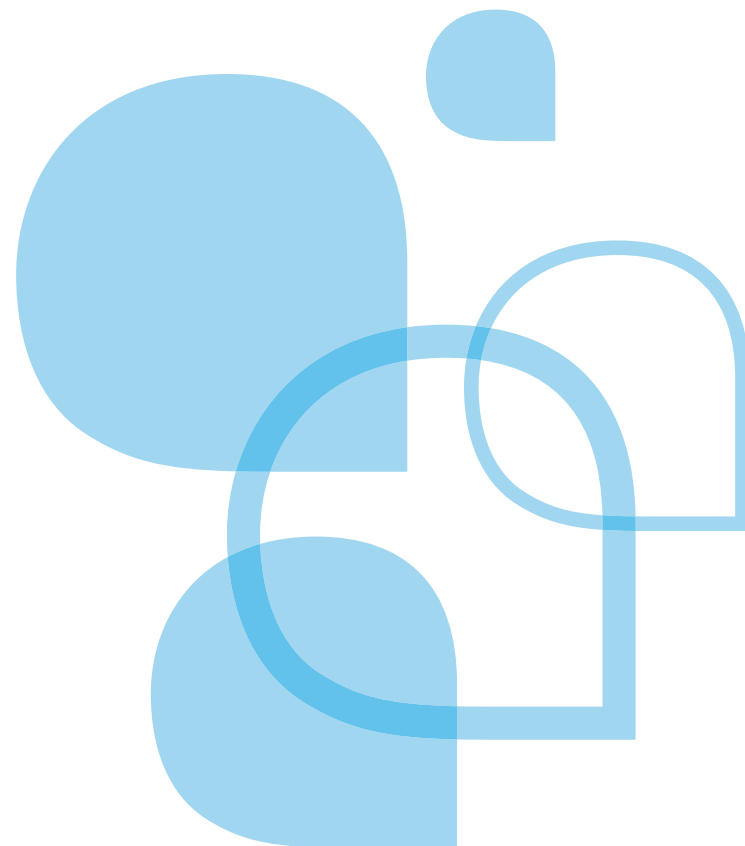
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Occupational Health Assessment and Control Measures for Volatile Organic Compounds (VOCs) in the Oil and Gas Industry

By **Yousef M. Al-Reshiadan,**
Environmental Protection Department

Volatile Organic Compounds (VOCs) are a group of chemicals that are commonly found in the oil and gas industry. These compounds are released into the air through the extraction, production, transportation, and storage of oil and gas products. They have the potential to be harmful to human health and the environment when safe exposure levels are exceeded, due to their toxic and flammable nature. This article discusses the occupational health assessment of VOCs in the oil and gas industry, including area and personal monitoring, and various measures to control VOC related health hazards in the workplace environment.

Occupational Health Assessment of VOCs in Oil and Gas Industry

VOCs can have a range of adverse effects on human health, including eye, nose and throat irritation, headaches, dizziness, and nausea. In severe cases, exposure to high levels of VOCs can lead to long-term health issues, such as respiratory diseases and neurological damage. To minimize these health risks, it is essential to assess the potential VOCs exposure to the oil and gas industry workers.

There are two main approaches to measuring VOCs exposure in the workplace: area monitoring and personal monitoring. Area monitoring involves measuring the ambient air concentration of VOCs in the general vicinities of the workplace. This type of monitoring is used to identify areas where emissions levels are high, and to determine the overall high-risk areas to workers. On the other hand, personal monitoring measures the exposure of individual workers to VOCs during their routine work activities throughout their work.

VOCs personal exposure monitoring is conducted by collecting air samples from the breathing zone of workers. This is done by placing a sampling media on a representative number of affected workers during a full work shift (e.g. 8 hours). The samples are then sent to an accredited laboratory and analyzed by various analytical techniques, such as gas chromatography and mass spectrometry. The results of these measurements are then compared to the acceptable occupational exposure limits adopted by the company and set by regulatory agencies, such as the Occupational Safety and Health Administration (OSHA) and American Governmental of Industrial Hygienists (ACGIH), to determine the potential risk to workers and take the appropriate corrective actions and control measures if needed.

Control Measures for VOCs in Oil and Gas Industry

There are number of control measures that can be put in place to minimize the impact of VOCs on human health and the environment. Some of the most common control measures include:

Engineering Controls: Engineering controls are designed to reduce the release of VOCs into the air. This can be done by modifying equipment or processes to reduce emissions, or by using ventilation systems to remove VOCs from the workplace.

Workplace Procedures: Workplace procedures can also be used to minimize exposure to VOCs. Safe working procedures should be used to minimize employee exposure to high risk tasks such as venting, purging, and confined space entry. This may also include providing workers with the appropriate protective equipment, such as respirators and training them on the safe handling of VOCs.

Substitution: Substituting VOCs with less harmful chemicals is another way to reduce the impact of these compounds. This can involve using alternative solvents or modifying processes to reduce the number of VOCs used.

Monitoring: Monitoring is an important part of controlling VOCs in the oil and gas industry. Regular monitoring of VOCs in the workplace can help to identify areas where emissions are highest and to implement appropriate control measures.

Regulations: Regulations are another important tool for controlling VOCs in the oil and gas industry. Regulatory agencies, such as OSHA, set limits on the concentration of VOCs that are allowed in the workplace.

Conclusion

VOCs are a common hazard encountered in the oil and gas industry due to their toxic and flammable nature and the associated risks need to be managed appropriately. To ensure that VOC compounds do not have an adverse impact on human health, it is important to assess the potential exposure to workers and to implement the appropriate control measures if required. These control measures can include engineering controls, workplace procedures, substitution, and monitoring. The Industrial Hygiene Unit (IHU) of the Environmental Protection organization is staffed with experienced industrial hygienists with the expertise and equipment to properly evaluate VOCs exposure in hydrocarbon facilities. Based on these evaluations, they can also provide recommendations, as necessary, to improve working conditions.



Figure 11: Utilization of direct measurement instrumentation to measure hydrocarbon occupational exposure at a facility by Lead Industrial Hygienist Ibrahim A. Al-Jabr, Saudi Aramco

Launching the “Little Green Hands” Community Outreach Program

By Ridha Abbas, Rakan Banna, Hani Baatiyyah & Ali Sultan, Sea Water Injection Department

SWID launched a community outreach program for school students to instill environmental sustainability lessons by hands-on experience. The program, “Little Green Hands”, was envisioned as a community outreach initiative, part of SWID’s strategic focus area on Sustainability.

During each event, every participating student and school staff plant a tree seedling at the Qurayyah Operation Support Building’s beach terrace. SWID Environmental Coordinators explain to students the important role which Aramco, via SWID, takes in environmental sustainability, especially groundwater conservation. Moreover, a representative from the Environmental Protection Mangrove and Forestation Division speaks to students about the importance of planting seedlings and preserving trees. Then, participants take a tour of the SWID Mangrove plantations.

Three events of “Little Green Hands” were conducted, covering both public and private schools, including schools for students with special needs and development disabilities. The ages covered elementary and intermediate school students. The program will expand to host an additional variety of schools and demographics. During 2022, more than 125 participants collectively planted more 350 tree seedlings. Key highlights included:

School	Date	Activity
Al-Faisal Intermediate Public School	8 June, 2022	SWID hosted 40 intermediate school students accompanied by two (2) school teachers. Together, they planted 150 tree seedlings
GEMS Saudi International Schools	20 Dec, 2022	SWID hosted 25 elementary school students accompanied by three (3) school teachers. Together, they planted 100 tree seedlings
ACCEL	22 Dec, 2022	SWID hosted 32 students with special needs and developmental disabilities. They were accompanied by 26 care takers, school staff, and administration. Together, they planted 100 tree seedlings.

Note that ACCEL (Ajyal Center for Comprehensive Education and Life Skills) is the school sponsored by Aramco

which provides educational, behavioral, therapeutic, and vocational programs to individuals with special needs and developmental disabilities. School staff conducted for students a session of therapeutic music. The visit was organized in collaboration with ACCEL's Aramco sponsors, Training & Development. They shared positive feedback from students' families and school staff.



Figure 12: Hands-On Tree Seedling Plantations & Real-Life lessons in Sustainability

What's next for Little Green Hands

SWID's is keen to further expand Little Green Hands program by targeting people from different communities in 2023, and to covers wide range of schools and universities students. SWID's will keeps evolving with new ideas and new ways to engage the community. SWID is planning to tag each tree to the child name and he can monitor the seedling that he planted by accessing a site online that shows them the location of the tree and how much carbon it has captured. This program was initiated to promote the environmental culture in alignment with Armco decarbonization strategy and green energy programs.



Figure 13: Al-Faisal Intermediate Public School (Public)



Figure 14: GEMS Saudi International Schools (Private) Photo-1



Figure 15: GEMS Saudi International Schools (Private) Photo-2



Figure 16: ACCEL (Special Needs & Developmental Disabilities) Photo-1



Figure 17: ACCEL (Special Needs & Developmental Disabilities) Photo-2

International World Days Calendar

By Rana AlGhamdi, Rawan Alyahya,
Green Energy and Environmental Policy Department

Enviro News is proud to bring you some key days and dates celebrated around the world over a calendar year. The purpose of these days is typically to raise awareness of significant environmental causes. Observance of such days is a wonderful opportunity to raise the profile of the specific situations, such as the plight of specific flora and fauna. Such days also serve other purposes, such as:

- Helping communities to establish partnerships on various causes
- Enabling individuals or organizations to begin environment and health campaigns
- Raising awareness on emerging “hot topic” issues

Day	Date
World Wetlands Day	February 2
Global Recycling Day	March 18
World Planting Day	March 21
World Water Day	March 22
Earth Day	April 22
Industrial Hygiene it’s called “World Day for safety and health Day”.	April 28
World Migratory Bird Day	May 14 & 13
World Endangered Species Day	May 19
International Day for Biological Diversity (World Biodiversity Day).	May 22
World Environment Day	June 5
World Oceans Day	June 8
World Wellness Day	June 11
International Day for the Conservation of the Mangrove Ecosystems	July 26
Zero Emissions Day	September 21
World Food Day	October 16

Sustainability Crossword Puzzle

Test your knowledge on a range of sustainability issues.

Clues

ACROSS	DOWN
3. Carbon ____ A generic term for any tradable certificate or permit deemed to allow a company, within an emissions trading scheme, to emit one ton of CO2 equivalent.	1. Able to break down and blend back in with the Earth
4. System of processes by which carbon moves through our Earth’s various systems (carbon ____)	2. Reflectance; the ratio of light from the Sun that is reflected by the Earth’s surface, to the light received by it.
6. ____ Emissions from the materials and products that a product, building or infrastructure project is made from and can occur right across the its life cycle	3. A measure of carbon inputs and outputs for a particular activity (two words:6,6)
7. To process materials that would otherwise be thrown away and turn them into reusable material.	5. ____ economy: Concept for reducing a society’s resource consumption and the resulting environmental impact through the use of multiple circular strategies like reduce, reuse, repair, repurpose and recycle
9. Changing behavior, production and systems to protect people, economies and the environment from the impact of climate change	8. An underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand, silt, or clay) from which groundwater can be extracted.
10. a dynamic complex of plant, animal and microorganism communities and their non-living environment all interacting as a functional unit.	

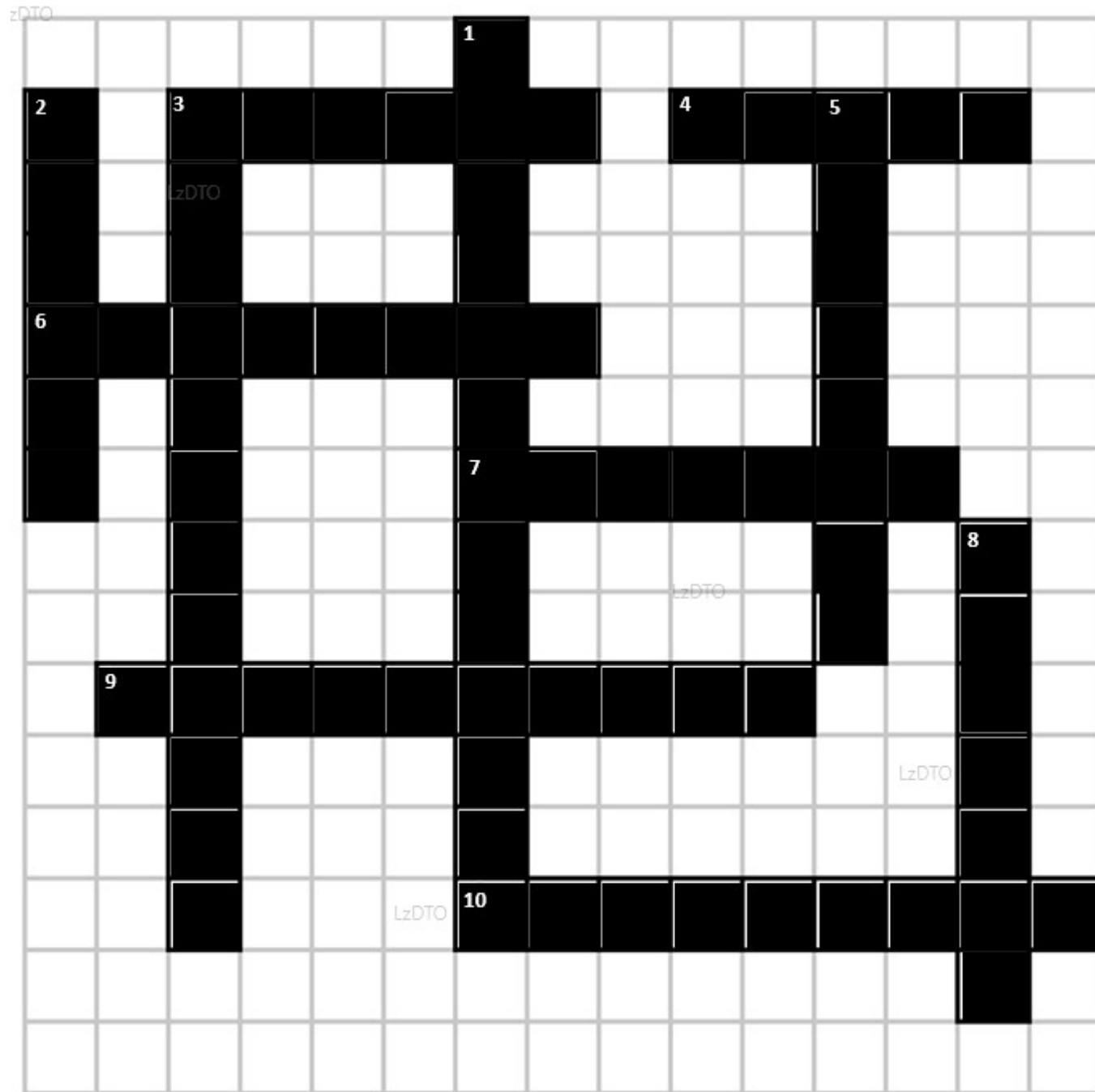


Figure 18: Crossword puzzle

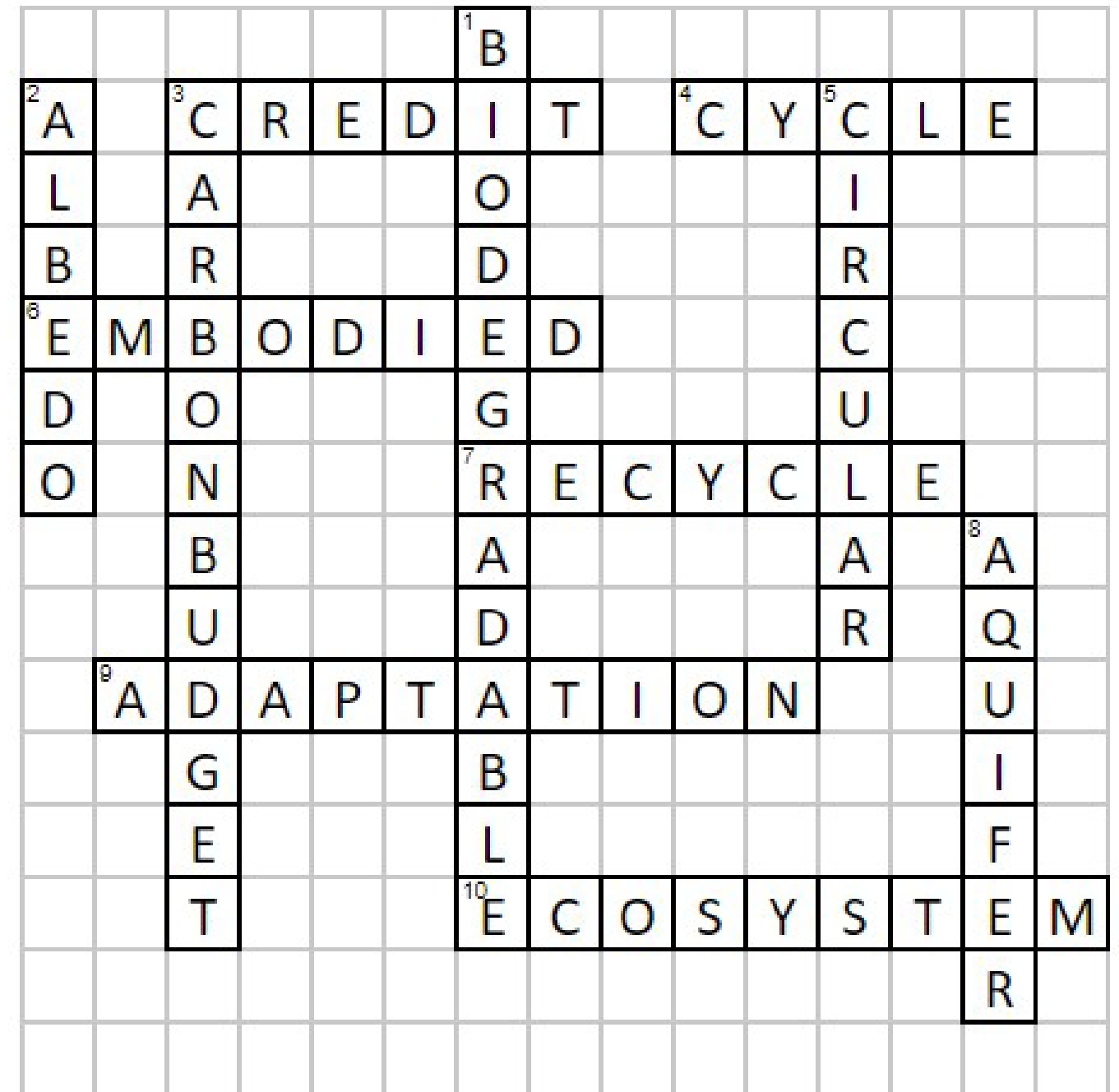
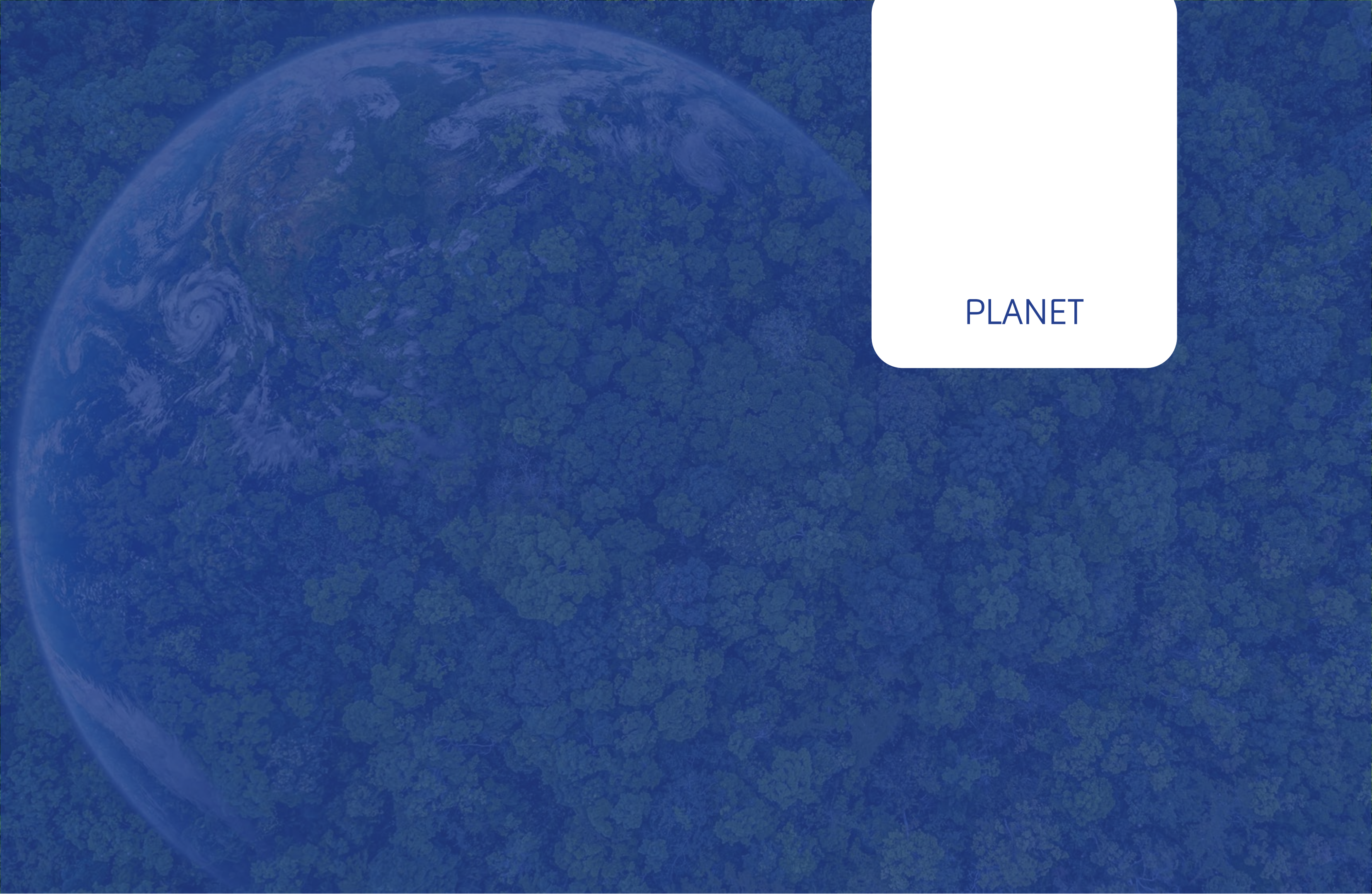


Figure 19: Answers to crossword puzzle



PLANET

Wings over Saudi Arabia

By Dr. Simon Attwood and Jana Al Turki,
Green Energy and Environmental Policy Department

Over the last couple of months, have you noticed there are greater numbers of birds around than usual? And not just numbers — an increased variety of shapes and sizes too, from elegant long-legged wading birds, to soaring birds of prey, to swifts and swallows performing aerial acrobatics as they swoop for insects. This is due to the amazing phenomenon of migrating birds.

Bird migration, has been occurring as a response to periodic changes in seasons for millennia, dating back to the last ice age and far beyond. In historical times, it was noticed and recorded by ancient Greek writers Homer and Aristotle over 3000 years ago. There are over 10,000 different species of birds in the world, and around 4,000 of these are migrants. Of these species, many billions of birds embark on epic migrations twice per year, between their breeding and wintering grounds. In many parts of the world, birds migrating en masse, create one of the most astonishing spectacles in nature. The cultural significance of migrating birds is profound, with swallows arriving from Africa being harbingers of Spring and renewal in Europe. Meanwhile, migrating birds such as the common cuckoo have been immortalized in the music of Beethoven and the poetry of Wordsworth.

World Migratory Bird Day (WMBD) is an annual global celebration of these intrepid avian travelers. This year's WMBD has the theme "Water: Sustaining Bird Life", and will highlight the importance of water for migratory birds and identify key actions for protecting aquatic ecosystems.

So, how does this relate to Saudi Arabia, one of the most arid countries on the planet? Firstly, Saudi Arabia is situated on one of the world's great 'flyways' (migration routes), with perhaps as many as 3 billion individuals of nearly 300 species travelling through the Kingdom between the non-breeding grounds of East Africa and the breeding areas of Eurasia.

Secondly, Saudi Arabia has a surprising number of wetlands, ranging from desert oases, to coastal lagoons and reedbeds, to well-vegetated wadis that only flow after rains, but which represent green arteries in these hyper-arid landscapes. In a region where much of the biodiversity is water-limited, wetlands are absolutely critical. This dependency includes migratory birds, all of which rely on water and its associated habitats, for migration, breeding, feeding, and wintering.

However, human activities such as intensive agriculture, urbanization, and other forms of development, plus pollution



Figure 20: Basra reed warbler (*Acrocephalus griseldis*) is an unobtrusive and globally threatened species. It breeds in wetlands in Iraq and Kuwait, with tall reeds and nearby tamarisks. On migration it occurs in fodder fields in the Eastern Province. It is regularly recorded in reedbeds and dense vegetation on Dhahran camp (Photo: Duha Alhashimi)

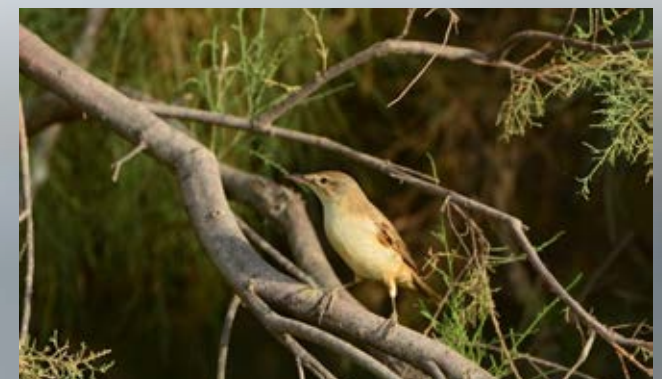


Figure 21: This highly migratory great reed warbler (*Acrocephalus arundinaceus*) occurs widely on migration (Mar–May, Aug–Oct) through Saudi Arabia and breeds in small numbers in the Eastern Province. It breeds in wetlands with tall dense reedbeds standing in shallow water. On migration it prefers wetlands, but also shelters in any vegetated habitat. It has been recorded on Dhahran camp in the last few weeks (Photo: Bader Al Qassim).



Figure 22: This large and globally Near Threatened Eurasian curlew (*Numenius arquata*) is primarily a passage migrant along the coasts. It frequents coastal mudflats, muddy bays, and open wetlands near the coast and has been recorded at several of Aramco's BPAs (Photo: Philip Roberts).



Figure 23: In Saudi Arabia, the black-tailed godwit (*Limosa limosa*) is fairly common on the coasts during the main migration periods (Mar–Apr, Sep–Oct) and over winter (Nov–Feb). Some immature birds stay for the summer, sometimes in large numbers in the Arabian Gulf. Breeds in open intertidal mudflats and sheltered bays, or less often on sandy shores and mangrove-fringed lagoons. Much like its close relative, the bar-tailed godwit (*Limosa lapponica*), it has been recorded at some of Aramco's BPAs (Photo: Sami S. Alreshoodi).

and climate change, threaten these ecosystems and the migratory birds that depend on them. Wetlands are among the most threatened ecosystems on the planet, with 90% of the planet's wetlands destroyed since the year 1700 and freshwater biodiversity having declined by a staggering 84% since 1970. Similarly, migratory birds are in serious trouble globally, with a recent study showing a serious decline in over half of the species assessed—this amounts to a net loss of 2.5 billion individual birds since 1970. Sadly, such declines are mirrored in Saudi Arabia, where wetlands are similarly at risk — for example, coastal mangroves have been removed in much of the Kingdom in recent decades, and migratory birds are impacted by an array of threats including hunting and habitat degradation.

How can Aramco and its employees do their bit to help our feathered friends and their aquatic habitats in particular? From a company perspective, a great deal. Aramco has so far designated about 980 km² of Biodiversity Protection Areas (BPAs), that offer feeding and resting opportunities for these global travelers. In a recent analysis, at least 92 species of migratory bird were found to have occurred at these BPAs. At least 50 of these 92 species are dependent on wetlands; this provides an excellent opportunity for Aramco to conserve migratory species on its BPAs and help contribute to national and global conservation efforts. Aramco is also embarking on a corporate “Wetland Strategy”, that includes a workstream to identify, prioritize, restore and protect natural wetlands on Aramco land, with priority sites intended to be designated as future BPAs. And close to home for many of us, Dhahran camp is something of a local biodiversity hotspot, with over 260 bird species recorded, many of these migratory. The wetland areas on the camp in particular are a magnet for migratory birds, with a wide range of herons, terns, ducks and wading birds recorded in recent years. Some of these species are truly internationally significant, with the globally endangered Basra reed warbler occurring in the reedbeds in Dhahran on its north-south migration route. Sympathetic ecological management and maintenance of these wetlands will enable these and other species to thrive into the future.

And as individuals, we can also contribute to our wetlands and the migratory species that use them. Sensible water use (not running water while cleaning teeth, shorter showers, full washing machine loads), planting a native garden using plants that a) are adapted to a dry climate and b) provide habitat for native species, keeping water clean where possible (e.g. reduce garden pesticides and herbicides) can all contribute if enough people adopt them.

Finally, keep a look out for migratory species in Spring and Autumn/Fall, and consider sending records to a global data recording scheme such as eBird (<https://ebird.org/home>) — collecting data through citizen inputs.

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Microalgae: A Promising Solution for a Low-Carbon Future

By Ahmad Tamimi, Ameerah Alkhalidi, Naif Almalki,
Green Energy and Environmental Policy Department

Algae can offset CO₂ remarkably

Group of aquatic photosynthetic and nucleus bearing organisms that lack true root, stems, leaves, and multicellular reproductive structures of plants. Algae photosynthetic pigments are more diverse than other plants, moreover algae cells have features that are not found among plants and animals. Why are algae valuable to us? Well it supports life, for example algae are highly diverse and can be found across the tree of life. Its high yield, efficient, and rapid growth can double its biomass in a day, which is important to note as this means a high CO₂ offset. Algae is making an eco-friendly species that can adapt to that native area, and can fight inefficiency biofuel. Algae can produce 50% oxygen and have less than 1% of all plant biomass. So, we have to

understand the value of algae and how it is beneficial to Earth's stability and nourishment. Nevertheless, if algae are not well understood it can demolish the performance and development of the country to reach our net zero goal.

Microalgae, tiny free-floating organisms, have captured the attention of scientists and researchers worldwide. Not only do they produce more than half of the oxygen we breathe, but they are also rich in bioactive compounds that have potential benefits in various industries. One area where microalgae are showing promise is in the production of biomass, which can be converted into biofuel, animal feed, and pharmaceuticals. This potential has caught the interest of many companies around the globe, including Saudi Aramco, who are exploring the use of microalgae as a nature-based solution to emissions management and mitigation.

Microalgae's simple tissue structure makes them highly efficient at converting sunlight into chemical energy. In fact, they can double their body size every day, making them an ideal candidate for biomass production. The idea of growing fuel in algae soup may sound futuristic, but it is a matter of timing. Our current oil and gas resources are derived from the remains of marine organisms, including algae, from millions of years ago. With the ability to grow and extract biomass from microalgae, we can bypass this lengthy process and produce fuel in a more sustainable and efficient manner.

One of the major advantages of microalgae is their ability to grow in various environments. They can thrive in both fresh and saltwater, including wastewater that would otherwise need treatment. Microalgae can even help purify wastewater

by removing pollutants and contaminants. Not only that, but these organisms also use industrial by-products like nitrogen oxides and carbon dioxide to fuel their growth. Ponds of wastewater can serve as nurseries for large volumes of microalgae, helping to reduce industrial emissions and release oxygen into the atmosphere.

Saudi Arabia, with its abundance of saline water, warmth, and sunlight, is particularly suited for industrial-scale microalgae production. The country's geographic suitability and existing resources for microalgae cultivation make it an ideal location. In fact, there are vast salt flats along the Arabian Gulf coast that can be converted into algae ponds. Furthermore, by using captured CO₂ emissions from industrial plants, microalgae productivity can be increased. Aramco has set up the first field-based microalgae testing facility in Saudi Arabia to explore the potential of algae-based biofuel and other applications, such as animal feed and sustainable fertilizers.

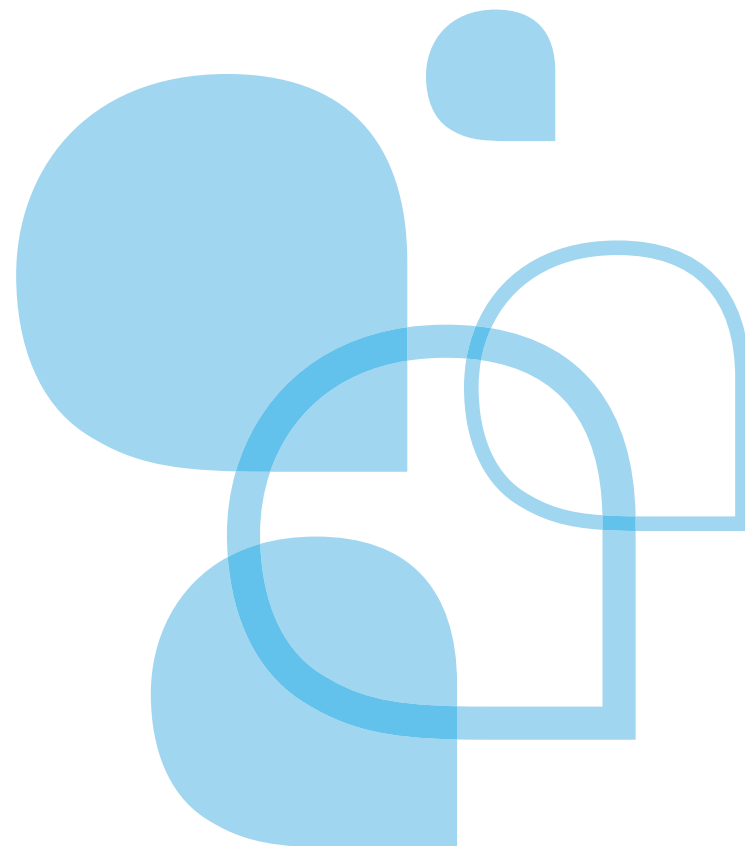
In 2021, Aramco successfully produced the first batch of biocrude from microalgae. This biocrude can be mixed with other oils and fuels to produce lower-carbon biofuels for transportation,

heating systems, and electric energy generation. The facility is also studying variations in microalgae growth across different years and seasons, as well as the capacity of different species to sequester carbon dioxide.

The goal is to scale up the production process and perfect it to ensure that biocrude from algae becomes a significant part of the future energy mix.

Beyond energy production, Aramco is exploring other applications of microalgae. For example, they are looking at converting algal biocrude into drilling fluids for upstream operations. Additionally, microalgae can act as a source of fertilizer for the mangrove trees that line the Arabian Gulf, serving as natural carbon sinks. Through their extensive research into microalgae, Aramco aims to maximize natural solutions and play a significant role in the global energy transition.

This exploration into microalgae is just one part of Aramco's mission to achieve a net-zero carbon footprint by 2050. As a sustainable and environmentally conscious company, Aramco is committed to making a profound impact in the battle against climate change. With the potential of microalgae and other nature-based solutions, Aramco is driving the transition to a lower-carbon future, aligning with the sustainability goals of Saudi Arabia and the world.



Endangered species Day

By Edward Bradbrook and Maareb Alsubhi,
Green Energy and Environmental Policy Department



Figure 24: "The richness of biodiversity is a reflection of our planet's health and vitality, and the ability of our ecosystems to sustain life."

The richness of plant and animal life on Earth is extraordinary and it is estimated that we share our planet with 8.7 million different species! It is teeming with life yet we have only officially identified and described around 1.2 million species, meaning that many more are yet to be discovered and remain a mystery to science. Although we have barely begun to understand the complexity and diversity of our natural world, the conservation status of many species is already threatened. Of the 150,300 species listed on the IUCN Red List, 42,100 are threatened with extinction.

This includes 41% of amphibians, 37% of sharks and rays, 36% of reef building corals, 34% of conifers, 27% of mammals and 13% of birds⁵. It has been estimated that monitored populations of animal species have declined by an average of 70% globally since 1970⁶ and the rate at which species are becoming extinct is accelerating as a result of human actions.

These alarming statistics highlight the fragility of the complex ecosystems which sustain life, including our own, and provide us with essential services on which we depend. Yet we have cause to celebrate the diversity of life on Earth and Aramco joined others on 19th May 2023 to observe Endangered Species Day. On this day, global citizens came together to raise awareness about the importance of protecting threatened and endangered species, and celebrate the successful conservation efforts to preserve them.

Endangered Species in Saudi Arabia

Saudi Arabia is located on one of the world's great migratory "flyways" (migration routes), with perhaps as many as 3 billion individuals of nearly 300 bird species travelling through the Kingdom between the non-breeding grounds of East Africa and the breeding areas of Eurasia. And the coastal waters of the Red Sea and the Arabian Gulf support mangrove, seagrass and coral reef ecosystems and a rich tapestry of marine life. Despite this surprising wealth of

biological diversity, the Kingdom of Saudi Arabia is not immune to the global biodiversity crisis.

According to the IUCN Red List of Threatened Species, 147 species in Saudi Arabia are near threatened, 113 are vulnerable, 40 are endangered, 16 are critically endangered, three are regionally extinct (Asiatic Wild Ass *Equus hemionus*, Cheetah *Acinonyx jubatus*, and Lion *Panthera leo*), one (the Arabian Oryx *Oryx leucoryx*) was extinct in the wild (but has since been reintroduced), and one (the regionally endemic Saudi Gazelle *Gazella saudia*) is globally extinct. Of the 21 extant endemic species in the Kingdom, only one is listed as least concern, and none are stable or increasing (IUCN, 2021).

Of the 401 bird species recorded with confidence in Saudi Arabia, 102 are listed as species of high conservation priority (Boland and Alsuhaibany 2020)³. The Asir Magpie (*Pica asirensis*) is considered to be one of the bird species of highest conservation priority within Saudi Arabia due to its endangered status (both globally and regionally), its small and decreasing population size (perhaps 100 pairs), small range (around 3,000 km²), and the fact that its global population occurs entirely within the Kingdom³. Saudi Arabia is also critically important for the conservation of the globally endangered Basra Reed-Warbler (*Acrocephalus griseldis*). More than 90% of the global population is likely to pass through the Kingdom on migration each year.

Similarly, the coastal waters of the Kingdom are teeming with life, with critically important coral sea grass ecosystems sustaining species of high conservation priority such as hawksbill turtle *Eretmochelys imbricate* and the dugong *Dugong*. The hawksbill turtle is listed as critically endangered on the IUCN Red List, and the dugong is listed as vulnerable and populations of these species are declining.

Aramco's Conservation Efforts

Aramco has a long history of working to protect and conserve biodiversity and we remain optimistic that we can collectively reverse the current trends in biodiversity loss and restore the conservation status of endangered species. Our Shaybah Wildlife Sanctuary in the unique landscape of the Rub' al-Khali (Empty Quarter) is a great example of our commitment to successfully achieving this vision.

Once a common sight, the Arabian Oryx graced the Rub' al-Khali for thousands of years, but their numbers were decimated by hunters over the past century to the point of near extinction in 1972. Despite this species being officially recorded extinct in the wild, it is a tremendous conservation success story, having been successfully reintroduced into its original habitat. Aramco's Shaybah Wildlife Sanctuary is one of these locations and now supports a thriving breeding herd, and the "unicorn of the desert" is once again a common sight.

Ras Tanura Turtle Rescue Center

The company also operates a sea turtle center, rescuing and rehabilitating sick and injured animals and returning them to the Arabian Gulf. The species most frequently encountered in Saudi Arabia's coastal waters are the green turtle *Chelonia mydas* and hawksbill turtle *Eretmochelys imbricate*. Both are listed on the global Red List of endangered species. Our rescue center is a critically important component of our strategy to protect and conserve these endangered animals and the marine ecosystems that sustain them. In collaboration with key partners we have also conducted extensive research and monitoring studies spanning decades, including satellite tagging and tracking of adult and juvenile turtles. Our research programs contribute towards an improved understanding of the ecology and movements of these species in the Arabian Gulf, and inform the development of actions to protect critical nesting and feeding sites.

Biodiversity Protection Areas

The protection and restoration of ecosystems is an essential pillar of our Company's biodiversity strategy, and our efforts to conserve endangered species. Our network of 14 Company biodiversity protection areas extends over 1000 km² and provide important refuges across the Kingdom for species of high conservation priority. These sites are home to more than 428 species of plant and animal, many of which are listed as high conservation priority species for the Kingdom, and include International Union for Conservation of Nature (IUCN) Red List threatened species. In a recent analysis, at least 92 species of migratory bird have been recorded within our network of Biodiversity Protection Areas, with these sites offering feeding and resting opportunities for these global travelers.

Endangered Species Day serves as an annual reminder of the urgent need to protect endangered species and the

ecosystems which sustain them. Join us in celebrating, learning about, and taking action to conserve and restore the diversity of plant and animal life on Earth for future generations.



Figure 25: Northern Bald Ibis, (*Geronticus eremita*), STATUS: (Critically Endangered) Extremely rare winter visitor, extremely rare passage migrant, possibly extinct. In summer (Jul–Aug), the Syrian population would fly south along the western highlands and Red Sea coast (up to five were in the ash-Shuqayq–al-Birk area in July 2010), spending the winter in wetlands in the southwest or crossing the Bab al-Mandab Strait (Yemen) en route to Africa. It would then return across the Red Sea to Jiddah (Mar–Apr) on its return north. HABITAT: Wetlands and marshy ground, such as dams, reservoirs and wastewater treatment ponds in the southern Tihamah coastal plain. It also appeared at temporary pools adjacent to farmland. (Photo: Ramon Valls).



Figure 26: Saker Falcon, (*Falco cherrug*), SAUDI ARABIAN STATUS: (Endangered) Rare passage migrant, rare winter visitor. This strong falcon can occur widely throughout Saudi Arabia over winter (Oct–Mar) with odd birds in other months probably on passage to Africa. HABITAT: Open deserts, including sandy and rocky areas with scrub, as well as farmland and coastal scrub. (Photo: Lee Marcus).



Figure 27: Eastern Imperial Eagle, (*Aquila heliaca*) SAUDI ARABIAN STATUS: (Endangered) Uncommon winter visitor. This genuinely imperial eagle is an uncommon winter visitor mainly to the northern plains and central regions. A census revealed that many spend the winter on the northern plains, making it perhaps the most important wintering area in the world. Satellite tracked birds captured while wintering near Taif flew to Russia, Kazakhstan, and China. HABITAT: Open steppe deserts. (Photo: Jem Babbington).



Figure 28: Arabian Oryx, (*Oryx leucoryx*), STATUS: (Vulnerable), In 1986, the Arabian oryx was classified as endangered on the IUCN Red List, and in 2011, it was the first animal to revert to vulnerable status after previously being listed as extinct in the wild. HABITAT: Arabian Oryx live in the Arab world, which encompasses Yemen, Oman, Kuwait, Qatar, and Saudi Arabia. This is a vast desert-heat region where sand dunes are common. They typically survive on the rocky mountain slopes of northwest Yemen. (Photo: Essam Al-Khulifi).



Figure 29: Hawksbill Turtle (*Eretmochelys imbricate*), STATUS: (Critically Endangered), currently classified as Critically Endangered by the IUCN (the global authority on the status of the natural world). HABITAT: Adults nest on sandy beaches, primarily under vegetation. Post hatchlings, small juveniles, and migrating animals are found in pelagic areas. Larger juveniles and adults forage in benthic habitats that include coral reefs and other hard bottom habitats, sea grass and algal beds, mangrove bays and creeks, and mud flats. (Photo: Jem Babbington).

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Aramco Restores Wetlands Biodiversity

By Simon Attwood, Dalal Dhamri,
Green Energy and Environmental Policy Department

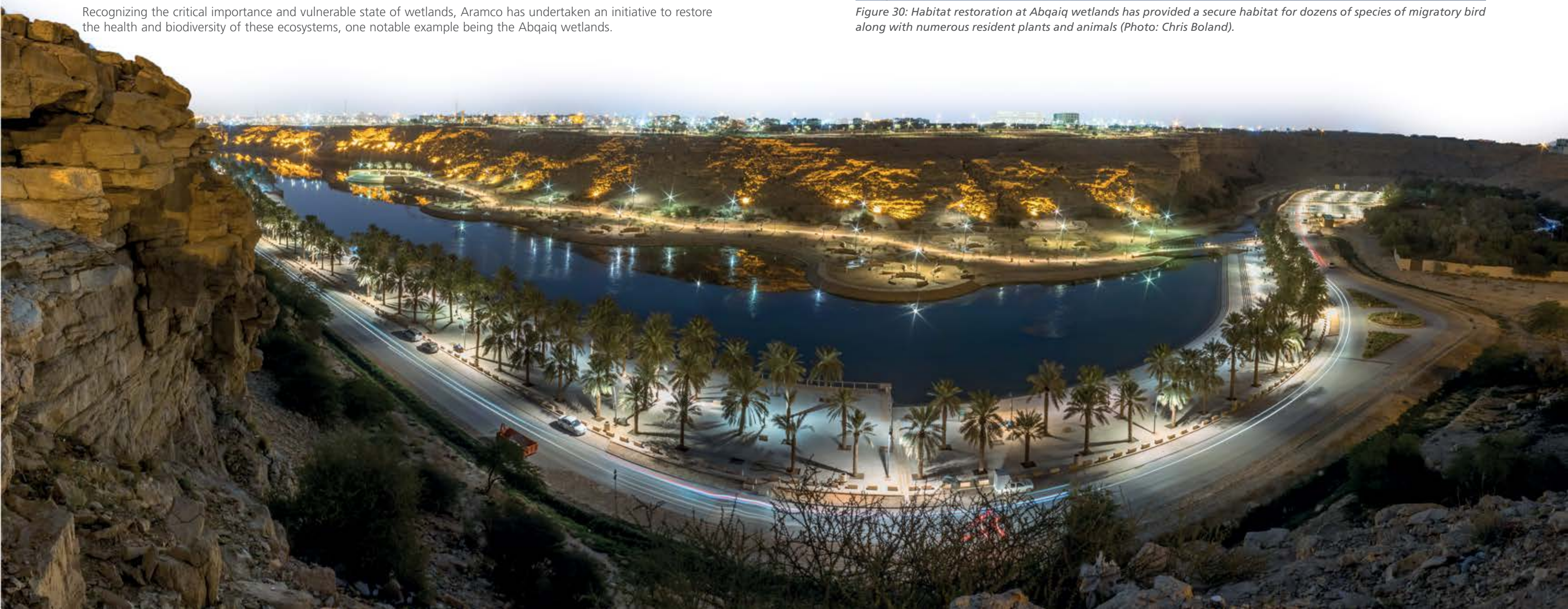
Saudi Aramco recognizes the enormous importance of wetlands and the vital roles that they play for both people and the planet.

Wetlands harbor a remarkable array of distinct ecosystems, teeming with a diverse range of wildlife such as amphibians, mammals, fish, dragonflies, and birds. These creatures have developed remarkable adaptations to thrive in their watery surroundings. Moreover, wetlands offer numerous “ecosystem services,” or benefits that nature provides to people without charge. These services include the provision of fresh water, flood prevention, climate regulation, and a source of sustenance. The impact of wetlands on food production is significant, with over 700 million individuals relying on aquatic agricultural systems for their livelihoods¹, as reported by the **Consultative Group for International Agricultural Research (CGIAR)**. However, wetlands face severe threats as they are among the most endangered ecosystems on Earth². affected by development-driven drainage, pollution, and the consequences of climate change.

Recognizing the critical importance and vulnerable state of wetlands, Aramco has undertaken an initiative to restore the health and biodiversity of these ecosystems, one notable example being the Abqaiq wetlands.



Figure 30: Habitat restoration at Abqaiq wetlands has provided a secure habitat for dozens of species of migratory bird along with numerous resident plants and animals (Photo: Chris Boland).



Abqaiq wetlands

Located near the Abqaiq community, the Abqaiq wetlands encompass an impressive 2.5 km2 of restored wetland habitat. These restored wetlands serve as a vital habitat for various native wildlife, including a rich diversity of migratory and wetland bird species such as the Western marsh harrier, Caspian tern, and spotted crane. To date, more than 90 plant, mammal, bird, and reptile species have been documented at the site, comprising both nationally and internationally significant species.

Previously, this area had been utilized as an unregulated solid waste dumping site. However, beginning in 2016, the company undertook a comprehensive restoration effort, which involved the removal of waste materials, installation of fencing to deter further dumping, control of feral dogs and cats that posed a threat to native animals, and the establishment of two birdwatching hides. Additionally, a sanctuary of reedy wetlands and a planted tree belt have been created to the west of the Abqaiq community.

In 2018, an impressive 25,000 native trees were planted at the site, and as they continue to mature, they provide additional habitat for numerous native species. These well-equipped facilities also offer guided recreational and educational opportunities for visitors to appreciate and cherish the restored wetlands.



Figure 31: Caspian tern an acrobatic visitor to the wetland habitats (photo: Bader Al Qassim)



Figure 32: Western marsh harrier – a bird of prey often found hunting over reedbeds (photo: Jem Babbington)



Figure 33: Spotted crane-a secretive and skulking marshland dweller (photo: Mohammed Al-Ruqaya)

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Mold: Unwanted Growth

By Majed AlArf,
Environmental Protection Department

Molds grow naturally in wet or moisture environments. Such areas can be water leaking roofs, wet windows, or pipes, or places that had flood. Furthermore, the microbes can grow well on damped paper products, cardboard, ceiling tiles, and wood under optimum conditions. Mold growth has also been observed on dust, paints, wallpaper, insulation, drywall, carpet, fabric, and upholstery.

As per the Center for Disease Control (CDC), indoor mold growth can be an indication of poor air quality and that the presence of visible mold spores, with clear evidence for convenient growing conditions that require attention for rectifying. In general, there are specific species of harmful mold spores by which human exposure can cause various health issues. Such issues include allergies, and respiratory illnesses such as a runny or blocked nose, irritation of the eyes and skin, and sometimes wheezing. Individuals with vulnerable respiratory conditions may further experience asthma attack as a result of mold spores exposure. (CDC, 2022)

In Aramco, the Environmental Protection Department (EPD) is the entity with the professionals who consult on indoor air quality related requests and conduct mold assessment investigations. Based on historical evaluations, growth of mold was revealed in many places in community buildings, houses, and site offices. In majority of such cases, mold growth was found in Heating, Ventilation, and Air Conditioning (HVAC) system with compatible mold growing conditions. Therefore, control of such conditions is very essential to avoid this unhealthy growing.

Mold Growth Reduction

EPD advises proponent organizations to effectively implement the Preventive Maintenance (PM) program in all Aramco facilities through implementing the Aramco Engineering Procedure (SAEP-402) designed for indoor air quality management, schedule cleaning and disinfection of HVAC ductwork and ventilation outlets via deep clean following manufacturer guideline. Also, all ventilation systems to be routinely inspected and cleaned, with record retention and robust tracking of actions.

Further attention needs to be focused on particular areas that have high potential for mold growth such as bathrooms, kitchens/coffee areas, and laundry rooms.

The Asthma and Allergy Foundation of America (AAFA) recommend mold growth reduction technique in the bathrooms by using an exhaust fan or open a window during baths and showers and run the fan for 30 minutes after bathing. AAFA also recommend removing bathroom carpeting from places where it can get wet. Additionally, scour sinks and tubs at least monthly due to fungi thriving on soap, other films on coat tiles, grout, and to quickly repair any plumbing leaks. (AAFA, 2023)

The other potential areas for mold growth are kitchens

As shown in the above figure, AAFA stated that it is important to clean garbage cans often and clean refrigerator door gaskets and drip pans and dispose of old items before they develop mold. Any plumbing leaks are ought to quickly repair. Finally, exhaust fans are useful to reduce humidity from cooking or washing dishes (AAFA, 2023).



Figure 34: Mold growth

Laundry rooms, are also one of the high potential areas for mold growth due to high humidity levels exist due to wet clothing if left for an extended amount of time. Therefore, it is recommended to remove clothes from the washing machine and dry them right away. Second, if you have a front-loading washing machine, clean and dry the rubber seal and inside of the door often. Leave the door cracked open when the machine is not in use. Also, don't leave wet and damp clothes sitting around. Finally, make sure your laundry area has good air circulation (AAFA, 2023).

It is important to ensure high level of cleanness at your house or office through getting rid of old books, newspapers, clothing, or bedding. It is recommended to check windows for condensation (water droplets or mist on the inside of your windows). As of general tips, air flow and fresh air should always be recycled throughout the rooms. One example of good practice to improve the air quality in the bedroom is to use a certified asthma and allergy friendly air cleaner.

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United States, Department of Health and Human Services, Centers for disease control and prevention. [Online]. Available at: <https://www.cdc.gov/mold/faqs.htm>

The background of the slide is a solid teal color. On the left side, there is a semi-transparent image of several hands stacked on top of each other, symbolizing teamwork or partnership. The hands are in various shades of teal, matching the background. One hand in the foreground is wearing a checkered shirt cuff.

PARTNERSHIPS

Riyadh Refinery Liquid Chlorine Dioxide (ClO₂) Injection in Water treatment: Water Quality Initiative

By Sibusiso Masuku, Abdulwahab Al-Shehri, Abdulaziz Al-Ghamdi, Riyadh Refinery Department

Introduction

Saudi Arabia, the land of rich resources of fossil fuels. And water. Yes, you read that correctly. Saudi Arabia holds two significant resource pools – oil and water. Deep water resources in the Kingdom were estimated to have once been as high as an incredible 500 cubic kilometers of water beneath the Saudi desert. Water in the country comes from only two sources: Deep wells and the sea. In the central regions, deep water resources are used, and much of this water has been pumped to the surface annually to cater for growing domestic demand for water. Away from the central regions, the Kingdom sources significant quantities of water from desalinated water. In fact, Saudi Arabia is one of the top global producers of desalinated water. According to the General Authority for Statistics, the contribution of desalinated water to the total fresh water available for municipal use in 2018 was 63%. Providing new sources of potable water is a matter of national strategic importance. With such great desalination water sources, the need for water treatment and purification methods has become much larger in the Kingdom. Traditionally, refineries – including Riyadh Refinery – have used chlorine gas (Cl₂) as a biocide (i.e. chemical substance or mixture intended to control or repel the growth of any harmful organisms) for water treatment.

The problem

Chlorine gas needs to be applied in larger volumes in water disinfection processes due to its susceptibility to water impurities including salts, pH, etc. This necessitates the use of greater volumes of chlorine gas to achieve the treatment required for water quality compliance standards. Unfortunately, there is an accompanying hygiene and safety concern since personnel are exposed to handling these large volumes. Furthermore, water quality maintenance is not easily achieved with the use of chlorine gas since it does not react with other water impurities and is also highly volatile. It is worth mentioning that Aramco has phased out the use of chlorine gas in water treatment facilities due to these reasons.

Why Liquid Chlorine Dioxide over Chlorine gas?

The use of liquid chlorine dioxide (ClO₂) for disinfection processes has been well known since its application as a disinfectant in the early 20th century when it was first used for water disinfection. Liquid chlorine dioxide has become the disinfection method of choice for Riyadh Refinery owing to advantages over chlorine gas in biocide treatment. The switch started during the 2017 trial with cooling towers, water surge pond injection in 2020, and the final unit to be switched was the water treatment plant gravity filter treatment in 2021. The biocidal properties of liquid chlorine dioxide are not affected by pH, whereas chlorine gas is only effective within a very narrow pH range, rendering it ineffective in most contaminated water grades. Chlorine dioxide is considered a stronger antimicrobial agent than chlorine gas. It is also a powerful oxidizing agent as it effectively oxidizes organically bound Iron, Manganese, and Sulfides at lower dosages than other oxidants that contribute to the water quality factor at different levels. The taste and odor, which comes from algae, and the breaking down of vegetation and phenol compounds are also reduced by chlorine dioxide. Chlorine dioxide is also more effective than chlorine and chloramine in inactivating the cryptosporidium and giardia parasites. Finally, chlorine dioxide is simple to generate and transport.

What has been done?

The environmental and health advantages of liquid chlorine dioxide treatment over chlorine convinced the Riyadh Refinery engineering team and its chemical treatment contractor, NALCO, to trial a new, fully automated biocide

treatment system (Purate Technology) in 2017 that uses liquid chlorine dioxide as a substitute to chlorine gas. The team introduced a compact dosing unit made up of a liquid chlorine dioxide generator (a reactor system that produces liquid chlorine dioxide), intermediate storage, and a comprehensive control unit. As shown in Figure 44 this modular system comes in a self-contained 40-foot container, with hookups to the base chemical pump supply and water that is used for the generation. The system discharges to the chemical dosing pipelines. Figure 45 illustrates the generation of chlorine dioxide in the system. The system uses Purate (a blend of sodium chlorate and hydrogen peroxide) and sulfuric acid to perform chlorate conversion, completely eliminating chlorine gas as a feed.



Figure 35: Outside view of the system



Figure 36: Inside view of the system

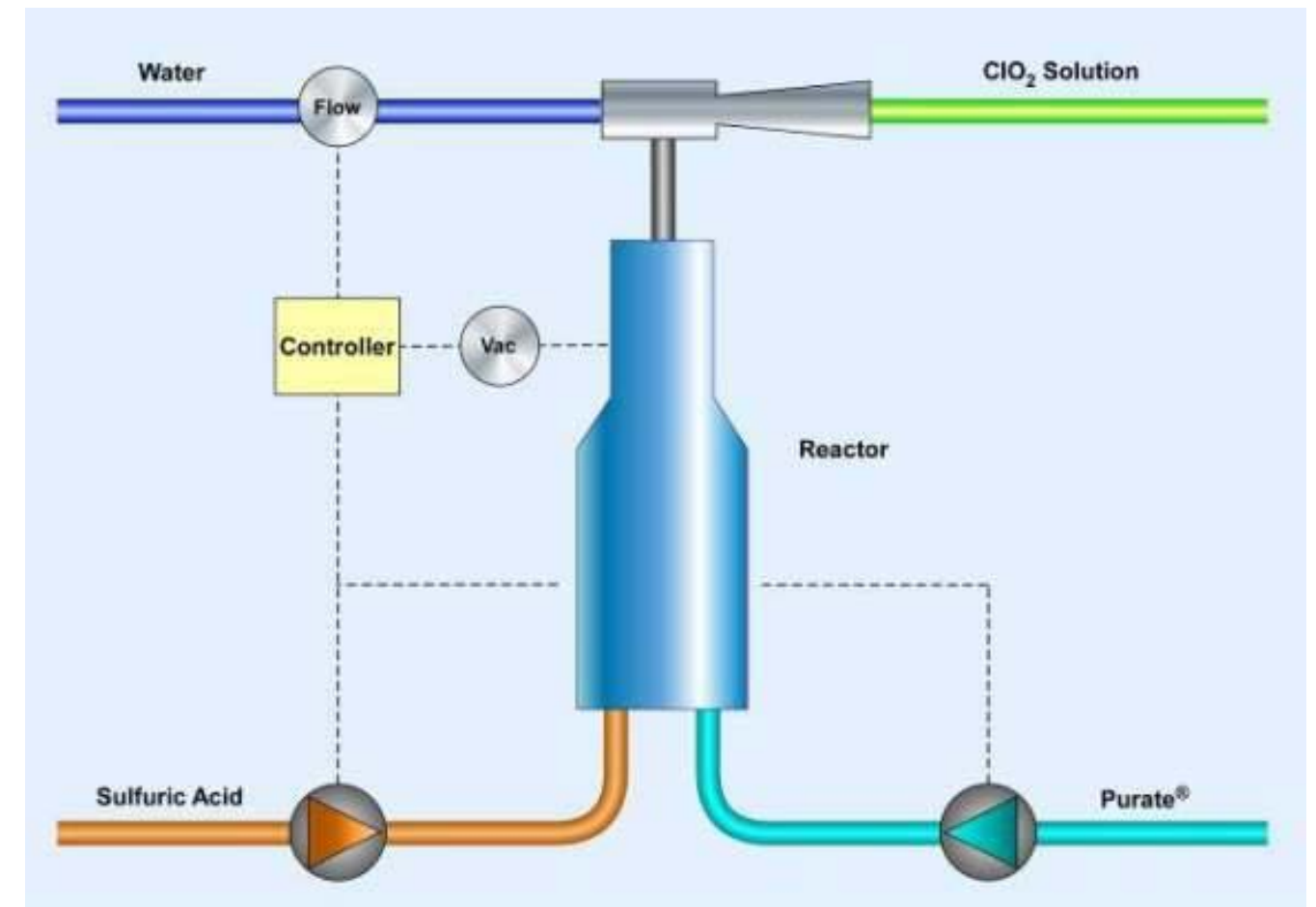


Figure 37: Scheme of the Purate Technology (source: Nalco)

Figure 46 illustrates the phenomenon of the ability of liquid chlorine dioxide to maintain higher amounts of residual chlorine, thereby being more effectively capable of treating biohazardous material in the water. In contrast, chlorine gas is consumed earlier by other organic impurities, and the pH inactivation leaves a very low concentration to effectively work as a biocide.

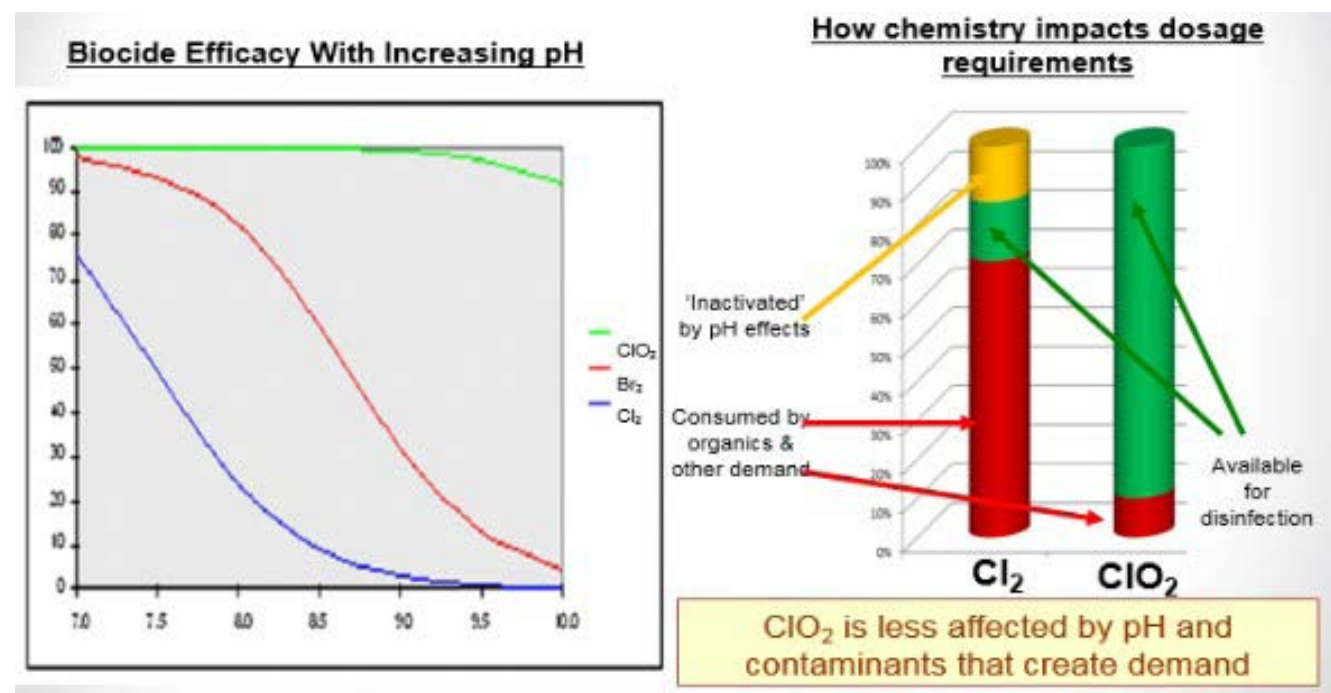


Figure 38: Efficacy of Liquid Chlorine Dioxide V.S. Chlorine gas with increasing pH (source: Nalco)

Due to the hazardous nature and handling risk of chlorine gas, the use of chlorine gas in water treatment is being phased out in favor of other more effective and environmentally less hazardous chemical treatments such as the Purate Technology. The trial revealed that chlorine dioxide is an effective treatment program for controlling biofouling. The cooling tower visual inspections and Oxidation Reduction Potential (ORP) measurements demonstrated a significant improvement in microbial growth control. A higher ORP level indicates that the water has a greater oxidation potential, which is an indication of superior system biofilm treatment performance. Since the beginning of the trial, the ORP improved from 200 to 500mv, suggesting better biofouling control. Moreover, the average corrosion rate of the cooling water system during the trial dropped from 1.5 MPY to 0.2 MPY, indicating a significant improvement in corrosion control.

Results and conclusion

The utilization of chlorine dioxide as a biocide has revealed several benefits for Riyadh Refinery. Implementing Purate technology has permanently eliminated the risks associated with chlorine gas. Also, the technology has enhanced the water quality up to a high compliance record of almost 100% in residual chlorine in all water classes across the refinery. Furthermore, the odors from Treated Sewage Effluent in the surge pond have significantly reduced. The introduction of the Purate technology has resulted in reduced use of chemicals owing to the virtual elimination of the need for chlorine gas. This has had an obvious financial benefit for the refinery. In conjunction with the environmental and safety benefits, it is already clear that this was a worthwhile investment.

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Enhancement of wastewater treatment quality control

By Abdulaziz Al-Ghowainem, Waleed Al- Qahtani, Saeed Al-Qahtani, Mohammad Badruzzaman and Jasim Al-Anazi, Environmental Protection Department

Introduction

Demands on water quality monitoring has increased substantially in the recent years due to stringent requirements of new environmental regulations within the Kingdom and internally. Traditionally, wastewater effluents are monitored for key water quality parameters such as pH, turbidity, chlorine, ammonia, nitrate, oil, and grease through grab sampling, which does not provide comprehensive and real-time quality of water/wastewater streams to be disposed of in the environment. Therefore, there is a contemporary need to utilize online analyzers to provide real-time key water quality data to plant operators to effectively manage/enhance process control and compliance.

Process control and early detection of non-compliance events are the key drivers of installing an online analyzer. In addition, online analyzers can be integrated with the existing or newly built wastewater/ sewage treatment plant to remotely monitor and keep track of its performance. Although instrumentation for monitoring of other physical, chemical, and biological water quality parameters is widely available, the hurdle in realization of true potential of online monitoring remains unexploited due to lack of information, end-user experience and other factors such as costs of analyzers, including operational and maintenance costs. A variety of analytical methods and technologies in online continuous monitoring have been developed and continue to advance, particularly in water quality detection application. Significant efforts are being made to enhance functionality and reliability of online analyzers to allow faster response and feedback to facility operators to enhance process control.

This study describes how the collaborative efforts among EPD and Aramco proponent facilities have installed advanced real-time analyzers to enhance wastewater treatment monitoring and quality control by monitoring critical parameters such as nitrate and hydrocarbon discharge to marine.

Technology Description

The technologies that have been implemented at Aramco recently are described below:

AN-ISE: Combination Sensor for Ammonium and Nitrate Monitoring. This sensor utilizes ion selective electrode technology and compensates for the most common interferences with integrated potassium and chloride electrodes within the cartridge. The compensation allows the sensor to provide accurate and reliable results. It is designed for immersion directly in aeration basins located in any conventional sanitary wastewater treatment plant eliminating the need for reagents and sample preparation and can be installed outdoors without additional housings, so it is easy to relocate to various locations.



Figure 39: AN-ISE visual representation for combination Sensor

AN-ISE sc: Combination Sensor for Ammonium and Nitrate (with RFID* technology) brochure



Figure 40: Ammonium and nitrate probe analyzer, By: Abdulaziz Ghowainem, onsite photo at Seawater water injection plant

EX-100P Advanced Sensor for Hydrocarbon in Wastewater Monitoring. This sensor uses the UV Fluorescence technique to determine Total Petroleum Hydrocarbon (TPH) content in industrial wastewater discharge. When exposed to UV or a Laser Induced Fluorescence (LIF) light source, aromatic hydrocarbons absorb energy and emit light at different wavelengths within instrumentation detection limits/range. The amount of hydrocarbon in water sample is based on the intensity of the light emitted.



Figure 41: Advanced Sensors EX-100P single in-line probe analyzer, Advanced Sensors EX-100P technology brief.

Deployment at Aramco Facilities

To comply with governmental environmental regulations, EPD tested and deployed online analyzers to monitor key Water Quality parameters in Waste Water discharges to marine environment and/or reuse streams.

AN-ISE visual representation for combination Sensor

Aramco Facilities	Analyzer Type
JUAYMAH NGL Fractionation Department	
YANBU NGL Fractionation Department	
YANBU Refinery Department	EX100-P Advanced Sensor for Hydrocarbon in Wastewater Monitoring
RT Refinery Department	
Western Region Terminal Department	
Udhailiyah Communities STP	
Abqaiq Communities STP	
Mubarraz Communities STP	AN-ISE: Combination Sensor for ammonium and nitrate
Sea Water Injection Department	
Shedgum Gas Plant Department	

Results

Cost Savings. Online analyzers automate all the major steps needed in traditional analysis such as grab sample collection, preservation, transportation, and sample analysis. Therefore, online monitoring of wastewater effluents has significantly reduced man-hours spent daily to conduct grab sample and laboratory analyses, resulting in operational and analytical cost savings. Preliminary estimates suggested that each installation might save significant amounts over the next 20 years for hydrocarbon to marine discharge monitoring. In addition, early detection of process upsets and implementing preventive actions can result in substantial cost savings in the future.

Risk Management. An important feature of online monitoring instrument is to serve as an early warning to alert Operations in the event of process and operational upsets that may result in poor performance or quality/standards non-compliance.

Monitoring. The installed online analyzers supported the company interest to enhance overall monitoring of the wastewater discharge quality. Online instruments provide vital data that can be used to assess environmental performance, view historical trends and performance, identify improvement opportunities, assist in setting targets, and enable facilities to benchmark with others.

Lesson learned

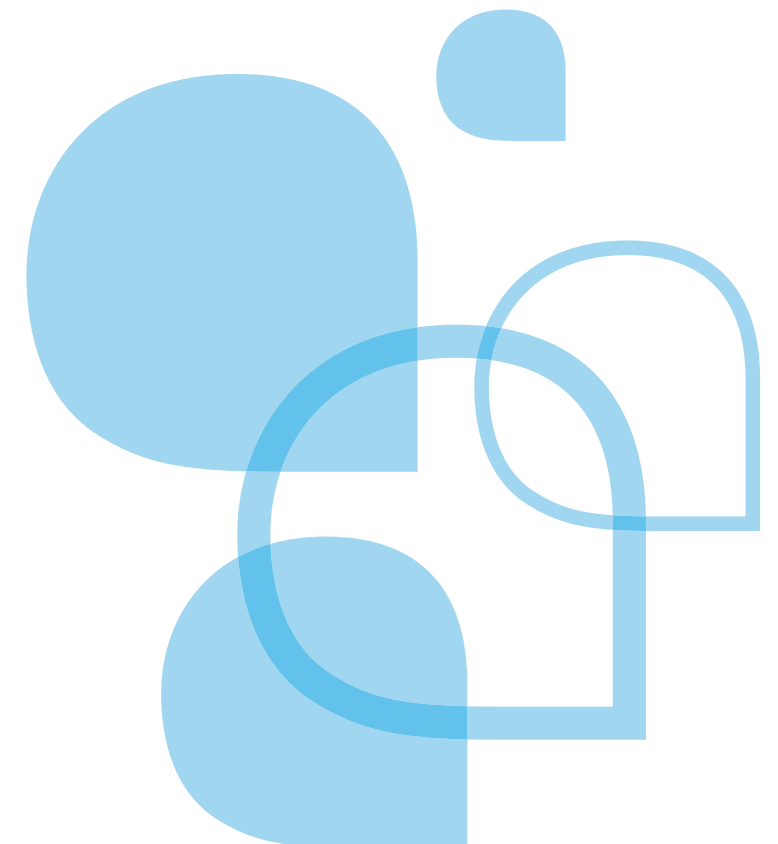
Although the benefits of using online instruments for monitoring water quality parameters are successfully demonstrated at Aramco facilities, a number of lessons learned must be considered to ensure accurate operation and successful maintenance. The following are some of the major challenges observed:

Lessons learned from Aramco installations

Item	Observations
Calibration and Accuracy	Irregular wastewater effluents with changing characteristics can cause maintenance issues and have to be recalibrated at frequent intervals leading operators to keep relying on grab sampling practice and laboratory analyses, in order to gain confidence and assure data quality obtained from online analyzer. It is essential to correlate and validate with laboratory data results used for compliance reporting.
Sensitivity and Selectivity	A number of factors must be considered before selection of online analyzer technology such as the measurement technique, range of detection levels, operating conditions etc.

Conclusion

There is considerable potential for the use of online analyzers to monitor pollutants content in wastewater applications and when successfully implemented. In conclusion, online monitoring can assist all Aramco facilities that generate water and wastewater to enhance their overall monitoring and compliance of water discharge to the environment. Online analyzers could be leveraged with the newly developed fourth industrial revolution center, additional features such as historical trend graph, limit exceedance alerts, exporting to excel, and through the use of advanced analytical tools, Aramco will be able to translate such big data into meaningful insight to predict its performance toward achieving corporate commitments and key performance indicators.



World Mangrove Day

By Ahmad Tamimi, Rawan Alyahya,
Green Energy and Environmental Policy Department

Environmental Protection through Green Energy & Environmental Policy Department launched a two-days awareness campaign (July 26- 27, 2023) in celebration of World Mangrove Day on July 26. The objective was to raise awareness about mangroves and their importance to ecosystems, while also showcasing Aramco's efforts as a pioneer in implementing nature-based solutions. Enriching people with the specific places that grows on which mangroves grow between the land and sea, creating dense coastline forests. In addition to mangroves types that reaches 80+ different species can be found across the globe in 121 countries. Saudi Arabia is host to two unique mangrove species that thrive in different climates: *Avicennia Marina* (Grey Mangrove) grows in the Arabian Gulf and the northern Red Sea, while *Rhizophora Mucronata* (Red Mangrove) grows in the southern Red Sea from Yanbu to Jazan. Moreover, sharing the fact of mangroves are the only trees that can survive in salt water and don't require irrigation. The most important shared information is the unique ability of mangroves that can sequester up to five times more CO₂ than tropical forests and can store it in their roots for thousands of years. They also absorb water impurities before they reach marine habitats and protect coastal communities from rising seas and storms.

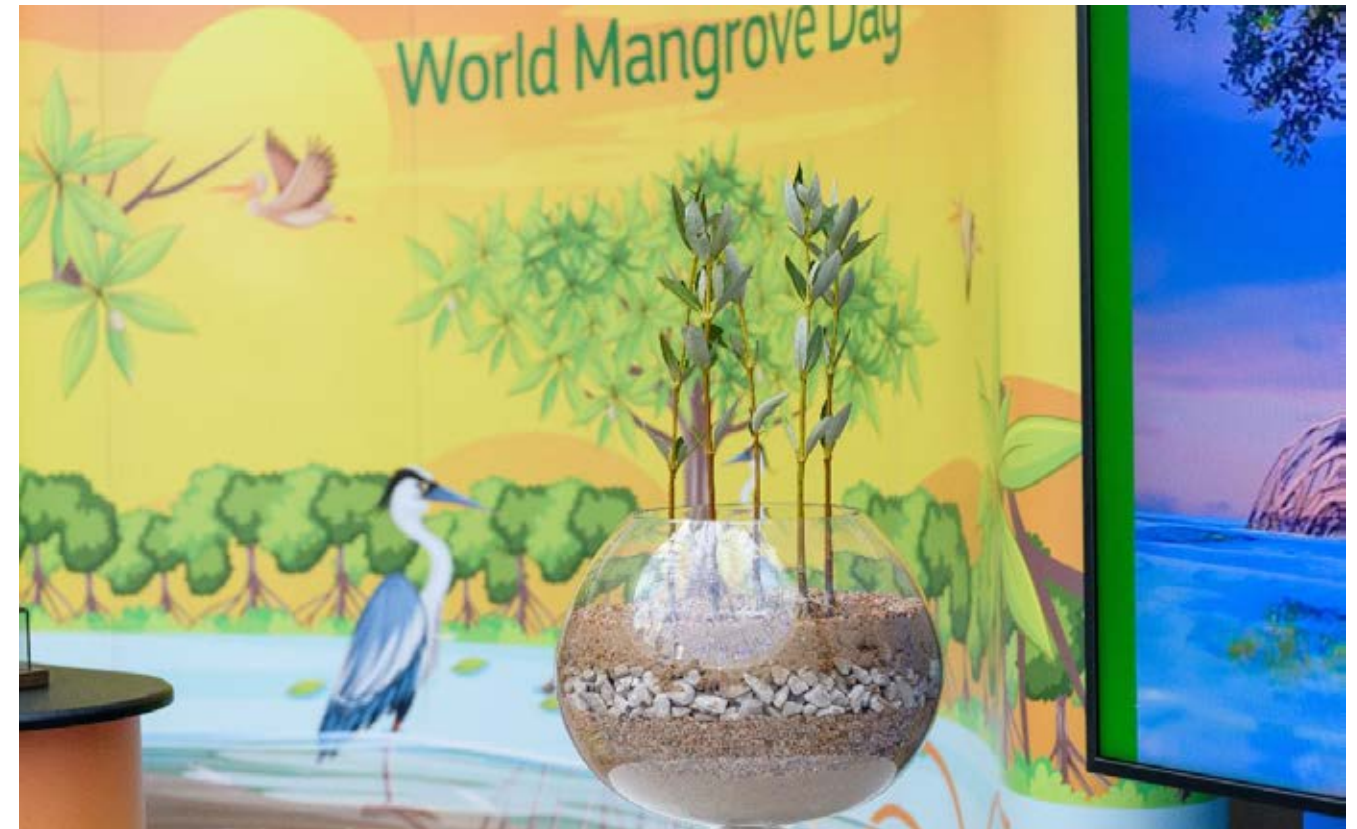
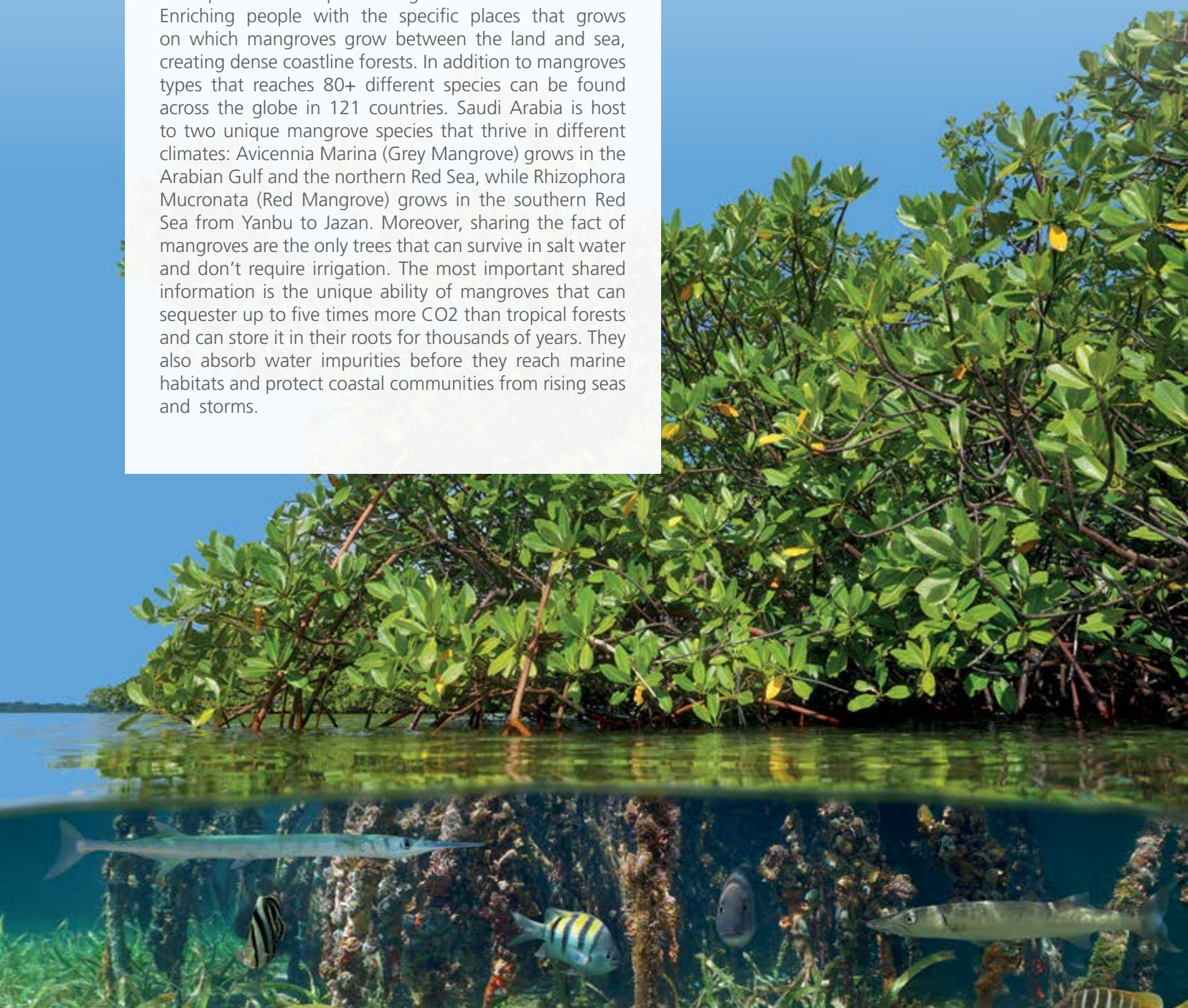


Figure 42: World Mangrove Day mural



Figure 43:EP delegates



Figure 44: EP SMEs



Figure 45: Sample

The campaign garnered significant reach and engagement represented by different advocacy channels which a corporate announcement was sent via email to over 70,000 employees across the company, ensuring broad dissemination of the campaign's message. In addition to an announcement posted on the popular myCommunity App, reaching more than 130,000 users, including dependents, this helped to extend the campaign's reach beyond Aramco employees. Moreover, screen tags were distributed to over 6,000 employees at Al-Midra and NP 1, 2 & 3 offices, this ensured visibility and constant reminders of the campaign's message to a targeted audience. Then, an engaging and educational booth was set up at Al-Midra, attracting over 2500 visitors, this provided an interactive platform for individuals to learn about mangroves benefits and significance. Supported with more than 650 informative brochures were distributed, allowing individuals to take home valuable information about mangroves and their conservation. Concluding with three informative videos about mangroves were shared through 43 E-Banner screens around the company, mass email, myCommunity App, and QR codes. This multi-channel approach ensured a wide distribution and easy accessibility to the informative videos. The success of this awareness campaign highlights the commitment of EP to advocate for the importance of mangroves and encourage environmental conservation. Aramco plants mangroves to protect vital ecosystems and contribute to a lower-carbon future.



Figure 46: EP Mangroves and Forestation experts.

