Business and environment report: Environmental outlook for the chemicals sector

The Environment Agency regulates a wide range of activities that affect the environment, people and the economy in England, from large industries to small companies and individuals. For our country to prosper we need to protect people and the environment, as well as support our industries to grow and innovate. As a regulator, we work to protect public health, improve air, land and water quality, and apply the environmental standards and regulation within which industry can operate.

Businesses we regulate can expect us to be proportionate, efficient, and easy to interact with. In return, we expect businesses to take their share of responsibility, take action to reduce their impact on the environment, and fully comply with their legal requirements.

This assessment sets out the progress made by the chemicals sector of industry working with us to achieve these aims and we would like to thank the Association of British Pharmaceutical Industries, British Association for Chemical Specialities, British Coating Federation, Chemical Business Association, Chemical Industries Association, International Fragrance Association UK, Solvents Industry Association, and the UK Cleaning Products Industry Association for their valuable input. It presents an overview of sector performance, impacts on the environment and a forward look to the challenges, risks and opportunities that the future presents.

Overview of regulation

As a regulator, the Environment Agency is responsible for implementing environmental regulations and standards set by government. We do this in a fair and balanced way, working to protect public health, natural resources and the environment, while supporting business and sustainable economic growth. Our role includes:

- monitoring and providing evidence on the state of the environment, to advise and inform government and others on policy development
- issuing permits to businesses and individuals, and setting standards so that businesses operate without harming people and the environment
- reviewing permits and guidance to make sure they are up to date and meet revised standards
- checking businesses and individuals comply with regulations and their permits
- investigating incidents and complaints
- stopping criminal and illegal activities that blight communities and the local environment
- using influence, advice and other complementary approaches to help businesses and industries achieve and maintain compliance with regulations and permits
- using appropriate proportionate sanctions and enforcement actions to bring businesses back into compliance, and using the full force of the law to crack down on illegal activities
- working closely with regulators who manage other environmental impacts such as local air quality, development, agriculture and industries with the potential for major industrial accidents

Our new Regulated Industry Strategic Business Plan 2018 to 2023 sets out how we want to see our work create a better place in 5 years' time and what we need to do to achieve that goal. We have identified 4 priority outcomes, which are:

- we support healthier and safer communities
- our work protects and improves the environment
- we contribute to economic growth
- people trust and respect our regulation

Our work will be focussed on delivering these outcomes, and we will report in future on the measures and impacts that demonstrate our progress.

Sector snapshot

In 2016, the chemicals sector (including pharmaceutical manufacturing) generated £17.8 billion Gross Value Added (GVA) (11% of total UK manufacturing GVA and 1% of GDP). It employed around 139,000 people. And it was the largest UK manufacturing export sector by value, even higher than automotive, with £53 billion of exports, comprising 9% of all UK exports.[1]

The chemical sector is a large, complex, mature sector with over 400 regulated installations, centred mainly in the north-east and north-west of England. It can be divided into 3 main sub-sectors:

Large volume organic chemicals (LVOC)

This sub-sector covers the continuous manufacture of organic chemicals typically produced in quantities of 20,000 tonnes or more per

[1] Sources: Office for National Statistics, HMRC and CIA analysis.

year. It has a wide range of plant sizes and process types, with the operators generally being large chemical or petroleum companies. The sector produces commodity intermediate products that are supplied to other chemical plants or companies, solvents and surfactants. Examples include hydrocarbons such as ethylene, alcohols such as ethanol and isopropanol, formaldehyde, organic acids such as formic and acetic acid, sulphur-containing compounds, nitrogen-containing compounds and halogenated compounds such as vinyl chloride monomer. The sector also produces several high volume polymers and resins, for example polyethylene, viscose fibre, and polyvinyl chloride.

Speciality organic chemicals

This sub-sector covers the manufacture of speciality organic chemicals on a small or medium scale, such as speciality surfactants, dyes, flame retardants, and fine organic chemicals such as flavours and fragrances. The sector also includes the chemical production of explosives, coatings products, pharmaceutical products and plant protection products.

Inorganic chemicals

This sub-sector covers a wide range of process types and plant sizes. It includes a number of large volume products such as ammonia, sulphuric and nitric acids, ammonium nitrate, chlorine and sodium hydroxide (chlor-alkali) (CAK), titanium dioxide and sodium carbonate.

The Environment Agency's Sector Groups work with industry and produce sector strategies and intervention plans for each sector. Information on the chemicals sector, including statistics for 2016, and how we will work with the sector from 2016 to 2020 can be found in the sector strategies published at www.gov.uk/government/collections/environment-agency-data-on-business-environmental-performance.

Successes in the sector so far include:

- compliance with permits is very good - regulation, engagement and co-delivery are working
- emissions of atmospheric pollutants from the sector have decreased significantly, reducing damage to health and the environment

Current areas for focus are:

- waste production and re-use, in particular hazardous waste
- Best Available Technique (BAT) Reference documents (BREF) engagement and implementation that require significant collaboration between regulators and operators, facilitated by trade associations such as the Chemical Industries Association (CIA)
- maintaining good environmental compliance and tackling persistent poor performers
- our organisational priorities, which include the EA's strategic review of charges, European Union (EU) exit, improving climate resilience, and adapting to changing energy markets

Challenges we expect ahead are:

- the circular economy
- emissions capture
- addressing the issue of pharmaceutical residues in the environment
- agrochemicals alternatives
- chemical waste treatment
- uptake/developments of new technologies
- evolution/continued application of green chemistry

These are discussed in detail towards the end of the report.

Successes so far

Environmental performance

The chemicals sector exhibits high environmental performance:

- in 2016, 98% of permits were in the Operational Risk Appraisal (Opra) good performance bands A, B or C for permit compliance (426 of 433 permits); 7 permits were in poor performance bands, down from 11 permits in 2014, and 9 in 2015
- no operators were prosecuted for environmental offences in the chemicals sector in 2016 - we issued only 1 enforcement notice and no cautions
- activities permitted under the Environmental Permitting Regulations (EPR) in this sector didn't cause any serious pollution incidents in 2016

Safety and environment are at the top of the chemical industry's agenda and for good reason. Many of its products are potentially hazardous at some stage during their manufacture and transport. Manufacturing processes frequently involve high temperatures, high pressures, and reactions that can be dangerous unless carefully controlled.

Many of the large chemical installations holding dangerous substances are additionally regulated under the Control of Major Accident Hazards (COMAH) Regulations, which came into force under the EU Seveso Directive. These are high profile sites and as such are inspected and audited for compliance regularly by our officers. We regulate COMAH establishments in England as a joint competent authority with the Health and Safety Executive (HSE). We also participate directly with industry and other UK regulators on COMAH matters, through the COMAH Strategic Forum.

Emissions to air

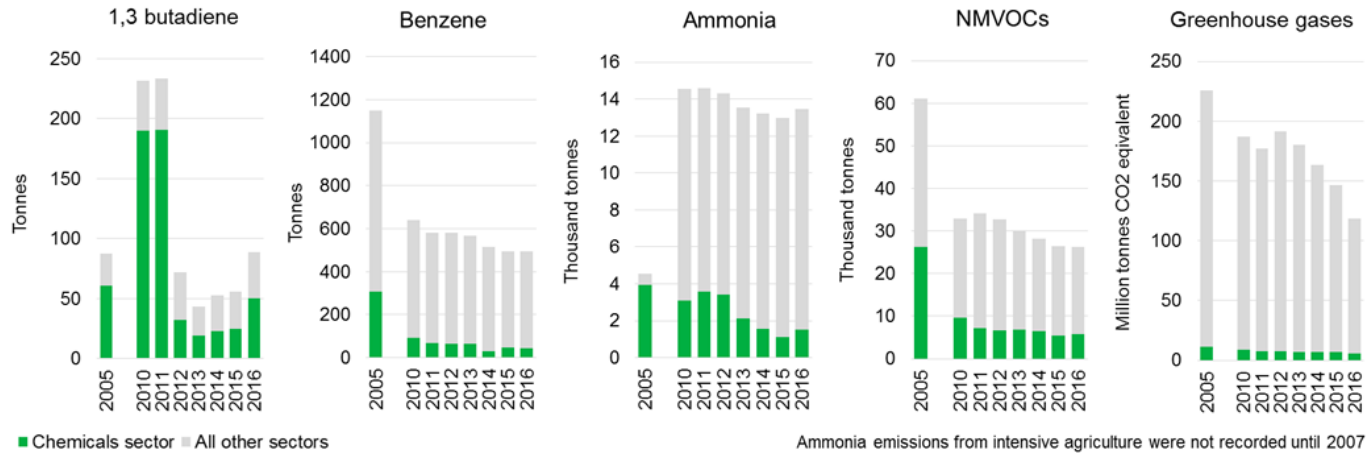
Emissions to air of potentially harmful substances from the chemicals sector that we regulate have reduced. Emissions of nitrogen oxides (NOx), sulphur oxides (SOx) and fine particles (PM10) from the sector have decreased by 40%, 73% and 91% respectively since 2005. The contribution of the chemicals sector to the total emissions from all the sectors we regulate under the Environmental Permitting Regulations is small (NOx, 5%; SOx, 2%; and PM10 <1%).

Since 2005:

- emissions of the carcinogens 1,3-butadiene and benzene have reduced by 18% and 86% respectively
- emissions of ammonia have reduced by 62%
- emissions of non-methane volatile organic compounds (NMVOCs), one of 5 pollutants specifically mentioned in Defra's 25 Year Environment Plan, have reduced by 78%

The contribution of the chemicals sector to total emissions of these substances are: 1,3-butadiene, 56%; benzene, 9%; ammonia, 11%; NMVOCs, 22% and greenhouse gases, 5%.

Emissions to air from the chemicals sector and all other sectors, 2005 to 2016



The changes, observed over time, have largely been a result of the UK implementing EU directives such as the Integrated Pollution Prevention and Control Directive (IPPCD), the Large Combustion Plant Directive (LCPD) and the Waste Incineration Directive (WID). In 2010 these directives were incorporated into the Industrial Emissions Directive (IED). They have required industry and businesses to change their working practices, as have other initiatives such as the industry-led voluntary Responsible Care scheme that seeks to continuously improve health, safety and environmental performance. Our role has been to work with industry to address sector-wide issues and ensure that these directives are met. We do this through compliance and enforcement, but also through reviewing and changing existing permits and requiring businesses to reduce their impact on the environment.

Volatile Organic Compounds (VOCs) react with other air pollutants to produce ground level ozone, which can damage crops and other materials. Inhalation of ground level ozone can exacerbate respiratory conditions such as asthma. Some NMVOCs, such as benzene and 1,3-butadiene, have been shown to be carcinogenic when there is sufficient exposure; in occupational settings for example. However, while Workplace Exposure Limits have been set for both substances, no absolutely safe level can be defined.

Ammonia has an unpleasant odour, which is detectable even at low concentrations. At high concentrations it can harm vegetation and aquatic organisms.

Fluctuations in emissions of some substances in recent years can be attributed to changes in production levels at a small number of sites, or even a single site that emit these substances. In 2016, two large sites significantly reduced their annual emissions profile to air, reducing VOCs, hexane and dichloromethane, by installing cryogenic abatement technology successfully on their manufacturing plants.

The chemicals sector that we regulate released 5.9 million tonnes of greenhouse gases (as CO_2 equivalent) in 2016. This was 2% of all greenhouse gases released in England. Releases of greenhouse gases from the chemicals sector that we regulate have fallen by 47% since 2005. The sector has committed to lower its carbon emissions and improve energy efficiency further in its joint industry-government decarbonisation plan.[2]

[2] Chemicals Sector, Joint Industry - Government, Industrial Decarbonisation and Energy Efficiency Roadmap Action Plan, October 2017 (www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-action-plans).

Current areas for focus

Waste

Waste re-use and recovery helps the environment by making better, more sustainable use of natural resources and reducing the need to dispose of material. Reducing waste also represents an opportunity for businesses to save money through reduced waste disposal costs, and improved use of raw materials.

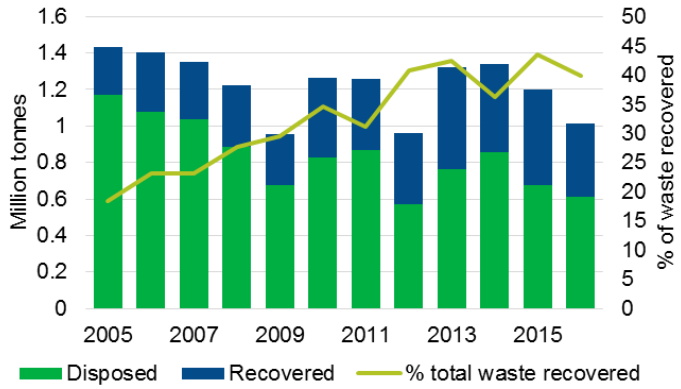
The chemicals sector produced just over a million tonnes of waste in 2016; 7% of the total waste produced by all the sectors we regulate. The sector has reduced the amount of waste it produces by 29% since 2005. It recovered 40% of its waste in 2016, up from 18% in 2005.

In 2016, 38% (0.4 million tonnes) of the waste produced by the chemicals sector was hazardous waste, slightly less than the amount produced in 2005. Only 25% of this waste was recovered in 2016, compared with 30% in 2005.

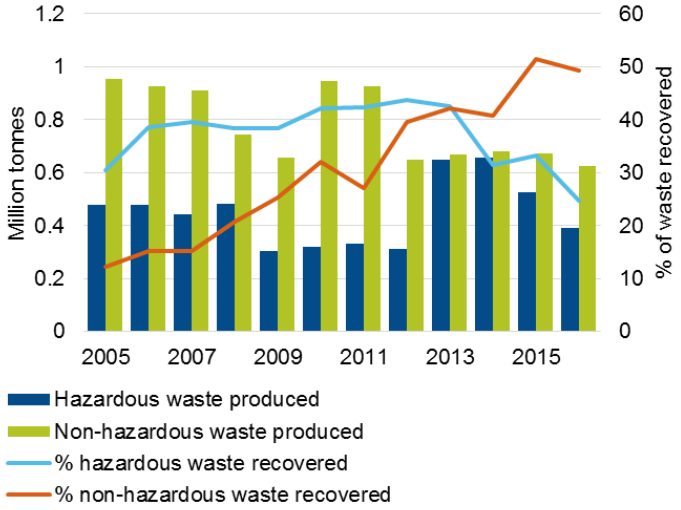
75% of this hazardous waste comes from the production of organic chemicals. Most of it is aqueous washing liquids and mother liquors from the production of basic and fine chemicals and pharmaceuticals.

More than half (57%) of the hazardous waste produced by the chemicals sector is sent for treatment and then disposed. 13% is incinerated as a means of disposal, that is, not as a fuel to generate energy. 7% is incinerated to produce energy.

Waste produced by the chemicals sector



Hazardous and non-hazardous waste produced by the chemicals sector



Fluctuations in the amount of waste produced can be linked to changes in product portfolio, and general manufacturing output in this sector. For example, some sub-sectors have higher waste intensities (tonnes of waste per tonne of product) but produce higher value products. Other reasons for the variations in waste data over the last ten years or so include changes in the classification of waste owing to changes in regulations, guidance or regulatory decisions.

Recovery routes for hazardous waste can be limited and waste may have to be transported a long way, or be exported, for recovery. Some hazardous waste solvents, thinners, oils and residues can be used as secondary liquid fuels in cement manufacture.

BREF engagement and implementation

The IED requires that environmental permits comply with the legally binding BAT (Best Available Technique) conclusions and BAT-AELs (Associated Emissions Levels) that are set in the BREF documents. This is achieved through the exchange of information between EU Member States, the industries concerned, non-government organisations promoting environmental protection, and the Commission.

The chemicals sector is complex and diverse and has the greatest number of BREFs of any sector that falls under the scope of the IED. Out of the total number of 42 BREF documents, nearly 22 either directly or indirectly apply to the chemicals sector.[3]

The Chlor-Alkali (CAK) BREF was completed in 2013, the Common Waste Water and Waste Gas (CWW) BREF was published in 2016, and the Large Volume Organic Chemicals (LVOC) in 2017. Work to develop the Waste Gas for Chemicals (WGC) BREF has just started. Other BREFs such as the Large Combustion Plants and Waste BREFs are also of relevance to the chemicals sector.

We implement the tougher standards required by the IED through permit reviews, which are a requirement of the IED. New permit conditions are set in line with the BAT conclusions and are implemented within a 4 year timeframe when the BREF relates to the primary activity of an installation unless there are site specific circumstances. This review process has just started for the LVOC sub-sector.

Maintaining good environmental compliance and tackling poor performers

Of the 7 permits, in the poor performances bands D, E or F, 4 have been rated as poor for 2 or more consecutive years and the operators classed as persistent poor performers. The problems at these sites include permit breaches, a lack of appropriate monitoring for emissions to air, storing too much waste on site for too long, and chemicals loss of containment into a local watercourse. One of the sites has been rated as poor for 4 years.

We have increased our regulatory effort at these sites through increased inspection, audit and enforcement action. Several of the sites are working on solutions, but they will take time to fully implement.

Strategic Review of Charges

Last year we set up a programme of work to reform our charging schemes between 2018 and 2023. As a result of this, new charging schemes were brought in from 1st April 2018 which reduce our reliance on public money, ensure we are compliant with Treasury guidelines and ensure our charges are simple, fair and effective. The charges are based on customers paying for the amount of regulation received.

EU Exit and REACH

The majority of environmental regulation and standards that apply in England are currently derived from European Union legislation. Ensuring continued protection of people and the environment when we leave the EU in March 2019 is one of our ongoing priorities.

We have been supporting government (principally Defra and the Department for Business, Energy and Industrial Strategy (BEIS)) in their work to ensure current levels of protection will be maintained, and to identify future opportunities for more effective and efficient regulation. More specifically, we have been working closely with relevant departments and other regulators to ensure EU derived regulations are retained as part of UK law. In several areas of regulation (such as Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)) this has involved very substantial input to the government's thinking and planning for the future.

In parallel we have been checking that our internal processes and systems will remain relevant and functional after Exit Day and are putting in place appropriate actions and resources to address any issues and communicate with our customers. Since the 2016 referendum, we have been careful to emphasise to our customers that current standards, guidance, and our expectations as a regulator remain the same.

[3] Chemical Industries Association, 2017. Position statement: Industrial Emissions Directive. (www.cia.org.uk/Portals/PositionStatement.pdf).

The UK's exit terms from the EU are critically important for the chemicals sector. 60% of UK chemical exports are destined for the EU, and 75% of chemical imports arrive from the EU.[4] After the EU exit, UK chemical sales to the EU will need to continue to comply with product safety regulation including REACH, biocides and pesticides legislation.

The House of Commons' Environmental Audit Committee (EAC) has warned that the lack of clarity on the UK's future relationship with REACH and other aspects of the EU's approach to chemical management could cost jobs. It said that the exports of £15 billion worth of chemical products to the European single market every year could be put at risk if British businesses are not recognised under EU REACH regulations after March 2019. The committee also said that REACH would be difficult to transpose directly into UK law.[5]

The IED merged and simplified previous EU legislation, and facilitated the collaborative EU and UK formal information exchange process used to identify Best Available Techniques and prepare BAT Reference documents. This process defines the BAT standards written into EPR permits and used to regulate the sector. One of the main regulatory challenges after the EU exit will be to navigate the changes in the relationship the UK will have with Europe in this process, and thereby the way in which BAT will be determined for UK law.

Climate Change

The Environment Agency has three main roles on climate change, to:

- reduce greenhouse gas emissions from sectors we regulate
- permit renewable and low carbon technology
- increase resilience to a changing climate

The Environment Agency implements the UK government's Climate Change Agreements Scheme, Carbon Reduction Commitment (CRC), Energy Efficiency Scheme, Energy Savings Opportunities Scheme and the European Union's Emissions Trading System (EU ETS). These account for over half of the UK's greenhouse gas emissions.

We also lead the permitting and regulation of low carbon technologies, ozone depleting substances and fluorinated gases. We issue environmental permits for some low-carbon and renewable technologies, for example, hydropower schemes, anaerobic digestion and water source heat pumps. We also advise on new applications to build power stations to ensure that they can install technology for carbon capture and storage in the future.

We also factor the impacts of severe weather and a changing climate into our work. As a regulator, we work with sectors to better understand the potential impact of climate change on their operations and the environment. As an adviser, we work with businesses, such as infrastructure operators, to ensure that they have the right advice and technical information to account for climate change.

Energy markets

Electricity Market Reform (EMR) is the process by which the government sets policy to deliver affordable, reliable and low carbon electricity (the trilemma) to the GB electricity supply network. It is the process that ensures the lights stay on now and in the future and will enable the UK to meet its CO_2 emissions targets to 2050. As such, it includes policies to decarbonise the electricity supply in the short to medium term which

[4] Chemical Industries Association, 2018. Brexit priorities for UK growth. (https://www.cia.org.uk/Portals/0/Documents/Brexit update_March18.pdf?ver=2018-07-13-161418-410).

[5] House of Commons Environmental Audit Committee. The Future of Chemicals Regulation after the EU Referendum. Eleventh Report of Session 2016–17.(www.publications.parliament.uk/pa/cm201617/cmselect/cmenvaud/912/912.pdf)

could potentially enable the decarbonisation of our heat and transport network in the longer term by converting these to run off low carbon electricity.

We will appraise and advise Defra and BEIS on the potential environmental impacts of EMR and ensure that the environment is protected and enhanced in this process. By working closely with the Electricity Supply Industries though the EPR regulation of the many generating installations, we will ensure air quality is protected, water used wisely and waste minimised. We will also ensure that energy efficiency is maximised, ensuring CO_2 emissions are minimised.

Thermal combustion plants that we regulate under EPR all have a role to play in the electricity market, either as base loading plant or flexible peaking plant in the balancing market enabling intermittent renewable generation. We will regulate the environmental impact, having regard to how they operate and the role they fulfil in the electricity market. We will also support the development and deployment of new technologies such as heat networks, syngas and hydrogen fuel, carbon capture and storage, and battery storage, while ensuring human health and the environment are protected.

The chemical industry uses energy both as a fuel and as a raw material. The sector is energy intensive. It competes globally for product market shares and inward investment, and depends on secure and competitively priced energy supplies. In the UK, the chemical industry is paying more for gas as fuel and for electricity than many competing production locations. Industry pays over 50% more than the EU median and more than twice the price of gas in the United States (US). In the US, the shale gas 'revolution' has triggered investments in chemical capacity worth $150 billion this decade. While UK chemical businesses are installing facilities to import US feedstock, the development of indigenous supplies of shale gas could provide a more secure and potentially competitive source and improve the business case for further investments in UK chemical capacity.[6]

Challenges ahead

The circular economy

The aim of a circular economy is to use resources in a more sustainable way, keeping them in use for as long as possible, extracting the maximum value from them while in use, then recovering and regenerating the materials at the end of their life. A circular economy is regarded as a way to secure a sustainable future and enable businesses to thrive.

The chemical industry can continue to offer many solutions to "close the loop" and itself to move further towards a circular economy by:

- developing more efficient production, for example through clustering of manufacturers
- enable circularity in downstream industries by designing for recyclability and durability
- developing innovative products that increase the resource efficiency of consumer goods
- supporting the development of renewable resources through industrial biotechnology and synthetic biology
- optimising the use of waste by producing recyclable goods, developing innovative ways to recover and re-use the chemicals found in waste, and using other industries' waste as feedstock[7]
- create alternative business models such as chemical leasing - selling chemicals by the service they deliver instead of volume

[6] Chemical Industries Association, June 2017. Position statement: shale gas. (www.cia.org.uk/Portals/PositionStatementShaleGas).
[7] Chemical Industries Association, June 2017. Position statement: waste and the circular economy concept. (www.cia.org.uk/Portals/Circular_Economy20June2017.pdf).

One area of concern for the chemicals industry when applying the principles of a circular economy is the constantly evolving knowledge of the properties of chemicals and their hazards. For instance, it is not possible to assume that any virgin material put on the market and considered safe at one time can still be considered safe later in its life cycle.[8]

Emissions capture

Research continues into technology to capture the emissions from manufacturing and energy generation, and in some cases to make commercial use of the captured gases. Greener alternatives to current absorbents of chemicals such as VOCs could offer ways for installations to reduce their environmental impacts. Carbon capture and utilisation (CCU) and similar technologies provide a way for operators to earn revenue from their emissions by capturing, separating and turning them into useful products such as chemicals, fuel, batteries and plastics.

Providing solutions

Pharmaceuticals

Research into new generations of medicines will involve a move away from predominantly chemically based medicines in the future and an increasing number of new treatments reaching the market are already of biological origin. Future therapies will also use other new technologies such as gene and cell therapy, again reducing the use of chemically based compounds. Medicines using nanomaterials may also offer more targeted delivery of medicines at lower doses.

Agrochemicals

The agrochemicals and crop protection sector may be changing towards alternatives to synthetic chemical pesticides. For example, the use of nanomaterial applications, which are designed to have a higher efficacy and be more targeted towards, for example, specific insect infestations. This could have great benefits such as boosting seasonal crop yields.

There could also be opportunities to explore and exploit alternative pest management techniques such as the use of biopesticides, which are pest management agents based on living micro-organisms or natural products. At present there are strict regulatory restrictions across the EU on the use of biopesticides.[9] However, this could change post EU exit, subject to the future approach to Integrated Pest Management (IPM), as part of agricultural policy in UK. There are opportunities for developing biopesticides in IPM by combining ecological science with post-genomics technologies.

Chemicals and waste

Water treatment

Novel materials may provide better water treatment and pollution solutions in the future. Advanced filtration developments that employ nanomaterials and graphene, offer new ways to remove substances from wastewater. Discoveries involving less hi-tech materials also show promise.[10] It may be possible to ‘fine tune’ filtration to target specific substances.[11]

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[8] European Environmental Bureau, 2017. Keeping it clean: how to protect the circular economy from hazardous substances. (www.eeb.org/publications/83/waste-and-recycling/1651/keeping-it-clean-how-to-protect-the-circular-economy-from-hazardous-substances.pdf).
[9] Phys Org Greater efforts are needed to promote biopesticides. (www.phys.org/news/2017-05-greater-efforts-biopesticides.html).
[10] ETH Zurich Hybrid membrane creates stir on global market. (www.ethz.ch/content/main/en/news-and-events/eth-news/news/2017/06/hybrid-membrane-creates-stir-on-global-market.html).
[11] Star Tribune Nano sponge to soak up pollution. (www.startribune.com/university-researchers-invent-nano-sponge-to-soak-up-pollution/417072084/).

Chemicals from waste

Plastic waste shows potential as a raw material for liquid fuel.[12] Innovations in this field could lead to fuel conversion without the need for extreme heat or caustic chemical reactions. Other compounds could also be derived from plastics.[13] Studies of novel proteins and enzymes from micro-organisms that live on plant fibres could develop into new ways to produce high-performance, renewable plastic packaging alternatives and present opportunities for forestry and agricultural sectors.[14]

Wood waste could replace coal and oil as raw materials for producing vitamins, medicines, solvents, crop protection products, plastics and detergents, making their production increasingly sustainable. A recent discovery involves using bacteria fed on wood waste derived from paper production, to produce succinic acid, which is a building block of many chemicals including polymers, solvents and perfumes.[15] Chemicals derived from paper and pulp waste could also be the source of products such as fossil fuel substitutes, fragrances, bioplastics, pharmaceuticals, paint, and insulation foam.[16]

New and emerging technologies

This next section explores examples of advancements in science and technology that could have commercially important applications at the same time as potentially offering environmental benefits.

At the moment, the majority of chemicals are produced from oil and other minerals, which all have a finite supply. We need to have options that enable us to recover and re-use chemical components, or to use more sustainable starting materials such as biomass and organic waste.

Industrial Biotechnology is important in advances in this area. Its application to convert renewable feed stocks, particularly biomass, waste and carbon dioxide, into chemicals is a rapidly growing technology in which the UK has some important strengths.

Synthetic biology is a relatively new discipline, but has exciting possibilities for the development of specific organisms that will enable the production of specialty chemicals and many other products, including brand new products, that cannot be made in any other way.[17]

A new chemical process that uses oxygen directly from the air could make the production of several carbon-based compounds more efficient, and lower the overall impact of industrial processes on the environment. The process is more efficient chemically, is cheaper economically as the raw materials can be collected directly from the atmosphere, and has a lower environmental impact because there is less chemical waste.[18]

The ocean environment is likely to play a greater role in food, resource and energy provision. Ocean based installations containing algae could become important biochemical plants producing biofuel, fertiliser, pharmaceuticals and cosmetics.[19]

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[12] Express Recycling technologies turns plastic fuel. (www.express.co.uk/finance/city/760831/Recycling-Technologies-turns-plastic-fuel).
[13] News UCI Recycle plastic waste into fuel. (www.news.uci.edu/research/chemists-find-new-way-to-recycle-plastic-waste-into-fuel/).
[14] EC renewable packaging from agriculture waste. (www.ec.europa.eu/research/infocentre/article_36016).
[15] ETHZ Chemicals from wood waste. (www.ethz.ch/content/main/en/news-and-events/eth-news/news/2016/06/chemicals-from-wood-waste.html).
[16] Rebnews valuable product paper waste. (www.rebnews.com/news/recycling/scientists_find_valuable_product_paper_waste_product.html)
[17] KTN 4 key challenges. (https://www.ktn-uk.co.uk/perspectives/4-key-challenges-the-uk-chemical-industry-is-facing-today).
[18] Chalmers Oxygen makes raw material. (www.chalmers.se/en/departments/chem/news/Pages/New-method.aspx).
[19] University of Southampton Oceans more essential than ever. (www.southampton.ac.uk/news/2015/09/gmtt2030-report-launch.page).

Scientists have merged bacteria with nanomaterials to create artificial photosynthesis that can produce raw materials for many industrial processes. The nanowires convert sunlight into free electrons, which the bacteria consume and turn into chemicals such as acetate; a building block for other industrial chemicals that is normally derived from petroleum.[20]

Green technologies and corporate initiatives are looking to reduce the environmental impacts of the chemicals sector. There are several developments that suggest that the future of electronics production could become less chemically intensive. Battery technology based on graphite and quinines utilises abundant organic materials, rather than rare and often toxic metals.[21] The techniques to move from batch to flow production of chemicals are coming on-line, in some cases, which could reduce costs, solvent waste and the environmental footprint as processes are constantly 'tuned' to produce different substances.[22]

Summary of risks, challenges and opportunities

The chemicals sector needs to continue to demonstrate a high regulatory performance rating, and achieve a zero target for serious pollution incidents. The Environment Agency will continue to direct risk-based regulatory effort towards the poorer performing sites.

Implementation of the IED through permit review will continue to drive down emissions to air and water through the setting of new standards for the future. The chemicals sector needs to pursue newer, greener technology where possible, and phase out the use of solvents that have higher environmental impacts. Waste management continues to be a challenge; there needs to be higher recovery and lower disposal. The principles of a more sustainable business and circular economy are to be promoted.

The transition to UK legislation post the EU Exit provides a challenge into 2018 and beyond. The current levels of environmental protection need to be maintained, as well as identifying new opportunities for effective and efficient regulation.

[20] Technologist Artificial photosynthesis. (www.txchnologist.com/post/117010114545/in-significant-advance-for-artificial).
[21] Nanotechweb Quinones and graphite make green battery. (www.nanotechweb.org/cws/article/tech/64494).
[22] EC Green chemistry goes with the flow. (www.ec.europa.eu/research/infocentre/article_37997).