

2025 AFRICA REGIONAL REPORT ON APPLIED GEOCHEMISTRY

Applied Geochemistry Highlights: Trends and Issues in Africa, 2024 to 2025

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SUMMARY

Applied Geochemistry (AG) activities in Africa during 2024 and 2025 have focussed on those (activities) of relevance to public health, climate change and resource management. Public health activities have engendered studies on the circulation of toxic elements in geomedical systems (water, soil and air) affecting agriculture and the food chain; thus, leading to diverse nutritional diseases due to trace element imbalances. Research projects in these interconnected areas leverage new technologies (AI, **synchrotrons*) and address data gaps, with key trends including improved stewardship of mining waste such as 'acid mine drainage' (AMD), using technologies such as AI and bioremediation. The use of integrated geophysics for minerals and improving geochemical data generation for exploration gained ground during the period under review (2024 - 2025), despite challenges experienced in funding, infrastructure development, and data accessibility.

Key events and meetings with significant Applied Geochemistry constituents during 2024 and 2025 include the 39th Society for Environmental Geochemistry and Health (SEGH) Conference in Nigeria (01 to 04 July, 2024), the 30th Colloquium of African Geology (CAG30) in Kenya (23 to 27 September 2025), and the First International Edition of the Scientific Forum Entangling Geosciences and Chemistry (SciFo-EGC) Conference (EGC 6) in Cameroon (24 to 26 October 2024). New infrastructure developments focussed on setting up of modern analytical facilities, such as the new commercial geochemistry laboratory in Walvis Bay, Namibia which was launched by the global testing giant SGS to support the mining industry.

**Note: Synchrotrons are powerful cyclic particle accelerators that bend high-energy electrons using synchronised magnetic fields, causing them to emit intense, brilliant light (synchrotron radiation), ranging from infrared to X-rays. Synchrotrons are used in diverse scientific research like biology, medicine, materials science and palaeontology. Africa does not yet have its own synchrotron light source, but the Continent's scientists are gaining synchrotron access through international collaborations and training programmes like the UK's START project, and initiatives by organisations such as UNESCO and the African Light Source (AfLS) project.*

INTRODUCTION

Applied Geochemistry (AG) activities in Africa during the period of 2024 and 2025 (ranked in Table 1) have focussed on urgent issues such as attainment of improved clinical diagnosis of environmental diseases through better understanding of the link between geochemistry and disease causation (Medical

Geochemistry) using advanced modelling; managing the geochemical circulation of toxic elements in the water, soil and air environment in as far as it (element circulation) affects the geochemical integrity of agricultural systems for food security, and development of new geochemical data and technology (AI, big data) for mineral exploration, though hampered by resource availability and skill gaps.

Table 1. Ranking Africa's recent (2024 to 2025) Applied Geochemistry Output (Based on AI Assisted Internet Searches of 30.11.2025)

Rank	Area of Activity (Field campaigns; Research Projects; Scientific Meetings; Publications; etc.)	Output, 2024 - 2025	
		Number of Hits Returned by Bing Search Engine Using Keywords: "Africa"; "2024"; "2025"; #X; "Africa" As At 30.11.2025	%
1	Geochemistry and Health (Medical Geology)	11,300,000	13.8
2	Climate Change Chemistry	9,240,000	11.2
3	Chemistry of Water Pollution	9,160,000	11.1
4	Geochemistry in Agriculture	9,140,000	11.1
5	Chemistry of Air Pollution	7,820,000	9.5
6	Chemistry of Soil Pollution	6,160,000	7.5
7	Geochemical Data and Analysis	5,920,000	7.2
8	Marine Geochemistry	3,250,000	4.0
9	Mapping for Geochemical Database Compilation	3,170,000	3.9
10	Geochemistry in Mineral (Ore) Exploration and Identification	3,170,000	3.9
11	Urban Geochemistry	3,150,000	3.8
12	Analytical Geochemistry	3,060,000	3.7
13	Geochemistry in Waste Management [Including Wastewater Treatment *(AMD)]	2,920,000	3.6
14	Extraterrestrial Geochemistry	2,630,000	3.2
15	Isotope Geochemistry, Inorganic- and Biogeochemical Processes	2,080,000	2.5
	Total	82,170,000	100.0

*AMD = Acid Mine Drainage

#X = Area of Activity (As in Column 2)

1. GEOCHEMISTRY AND HEALTH (MEDICAL GEOLOGY)

Most of the diseases studied within the realm of Medical Geology are actually “geochemical diseases”, for they occur because of differences in the nature, dynamics of circulation and concentration levels of chemical elements, as well as the interplay of other biogeochemical factors (e.g., pH, bioavailability, bioaccessibility) of the elements involved in metabolic perturbations in the human body. As a result of the increasing awareness of the important role of geochemical variables in agricultural systems and the food chain as probable aetiological co-factors for certain environmental diseases in Africa (See, e.g., Davies, 2022; Davies, 2024), research and other geoscientific activities in Environmental Geochemistry and Health (Medical Geology) (ranked topmost in Table 1) continued to upsurge during the period of 2024 and 2025.

Africa’s key Geochemistry and Health events during the period of 2024 and 2025 include the 39th Society for Environmental Geochemistry and Health (SEGH) Conference in Nigeria (01 to 04 July 2024) which focussed on interdisciplinary research on Geochemistry and Health, featuring presentations, networking, and a field trip to lithium (Li) mines. Major themes in the SEGH Conference included emerging contaminants, climate change impacts, geo-health policy, and building capacity through student workshops and international collaboration, and bridging geology, medicine, and public health for better urban and rural health outcomes.

Other major activities during the period under review include the 30th Colloquium of African Geology (CAG30) in Nairobi, Kenya (23 to 27 September 2025), and the First International Edition of the Scientific Forum Entangling Geosciences and Chemistry (SciFo-EGC) Conference (EGC 6) in Yaoundé, Cameroon (24 to 26 October 2024). The establishment of the Jose A. Centeno International Centre for Medical Geology (JACMEDGEO) at the Nasarawa State University (NSUK) in Keffi, Nigeria for African and international students took place on 29 February 2025 and admitted its first class of students on 19 June 2025. The academic degree programmes include degrees in: Postgraduate Diploma (PGD) in Medical Geology; Master of Science (M.Sc.) in Medical Geology; and Doctor of Philosophy (Ph.D.) in Medical Geology.

A new book, “Medical Geology of Africa: A Research Primer” (Davies, 2024) was published by Elsevier in late 2024 to reiterate the link between geochemistry and public health in Africa and expose important gaps in knowledge in this rapidly evolving field. As the link between geochemical cofactors and myriads of environmental diseases in Africa becomes clearer and more firmly established, we will continue to see a rise in research activities in Medical Geology.

2. CLIMATE CHANGE CHEMISTRY

From 2024 to 2025, activities incorporating African climate chemistry focussed on green solutions, e.g., the ‘Elsevier Challenge’ for implementing green and

sustainable chemistry solutions in the Global South; assessing contaminant impacts from extreme weather, and the development of sustainable materials. The “Climate Chance Africa Summit” (27 to 28 October 2025) held in the Republic of Benin dwelt on the key climate chemistry theme of: “Renewable Energies, Adaptation, Biodiversity: Challenges and Perspectives”. In the context of growing climate emergency, pressure on energy access, and the urgent need to accelerate a sustainable transition, this Summit brought to the fore African solutions for a just, inclusive, and locally relevant energy transition.

The Africa Centre for Energy Policy (ACEP) inaugurated the Africa Climate Academy from 07 to 11 October 2024. This Academy is an educational platform designed to foster a change in thinking in the understanding and discourse surrounding climate change, energy transition, and its implications for Africa.

The “African Green Chemistry School and Environmental Sustainability” (GreenChemAfrica) represents a pivotal initiative aimed at addressing critical environmental challenges and promoting sustainable chemical practices across the African region. This School which was held from 21 to 27 April 2024 in Mohammed VI Polytechnic University, Benguerir, Morocco, focussed on programmes dealing with green chemistry and sustainability, emphasising the need for environmentally friendly chemical processes in the Africa region. It offered participants from across the African continent a world-class educational experience designed to stay up to date with the latest advances in green chemistry and environmental sustainability. High level training offered to PhD students, postdocs, and professionals on green chemistry solutions for environmental challenges positioned them to contribute effectively towards putting Africa at the forefront of sustainable technological innovation, creating pathways for more resilient and environmentally conscious development strategies.

3. CHEMISTRY OF WATER POLLUTION

Activities regarding water pollution chemistry in Africa from 2024 to 2025 focussed on addressing issues that range from poor handling of industrial and mining waste, agricultural runoff (agrochemicals, sewage), urban pollution, and climate change impacts. These issues are driving research, policy, and technological solutions like water quality monitoring, improved treatment at wastewater treatment plants (WWTPs), sustainable farming practices, and better governance under frameworks like the Africa Water Vision for 2025, aimed at securing clean water amidst increasing demand and scarcity.

A detailed itemisation of the key focus areas of research on water chemistry and pollution in Africa during 2024 to 2025 runs as follows: (i) Chemical Contaminants: Investigating specific pollutants from mining (toxic metals), agriculture (pesticides, fertilizers), pharmaceuticals, and emerging contaminants (microplastics); (ii) Impact on Aquatic Ecosystems: Assessing chemical effects on

biodiversity, nutrient cycles (N, P), and water quality parameters (BOD); (iii) Climate Change Nexus: Studying how altered rainfall (wetter or drier scenarios) affects pollutant loads and water quality; (iv) Research and Monitoring: Deploying advanced analytical techniques (e.g., spectroscopy, chromatography) for water analysis, tracking pollution sources; (v) Technology and Innovation: Developing affordable water treatment technologies (e.g., bio-filters, advanced oxidation) for rural/urban areas; (vi) Geochemical Modelling: Studies are using geochemical modelling to analyse groundwater quality for sustainable management, particularly in arid and semi-arid regions; (vii) Geochemical Evolution: Research continues on the geochemical evolution and mechanisms influencing groundwater chemistry in different regions of Africa; (viii) Policy and Governance: Strengthening national water policies, promoting integrated water resource management (IWRM), and regional cooperation (Africa Water Vision 2025); (ix) Sustainable Practices: Promoting agroecology, reducing chemical fertilizer use, improving waste management (sewage treatment, solid waste) and (x) Capacity Building: Training water professionals, raising public awareness about water hygiene.

4. GEOCHEMISTRY IN AGRICULTURE

Geochemistry activities in African agriculture (2024 to 2025) centred around soil health, nutrient management (especially P), toxic metal pollution, and climate adaptation. Major events such as the AU's Africa Fertilizer and Soil Health (AFSH) Summit held in Kenya (07 to 09 May 2024) set forth cogent action plans.

Research explored advanced techniques (spectroscopy, modelling) to assess element mobility, predict risks, and develop sustainable solutions for food security, often targeting critical mineral resources and trace elements in soils and water. The 10-Year AFSH Action Plan and Soil Initiative for Africa (SIA), which aims to reverse soil degradation, triple fertilizer production (organic/inorganic) by 2034, and improve farmer access to recommendations for better soil health, productivity, and food security was advanced. A listing of key research areas on geochemistry in African agriculture (2024 to 2025) runs as follows:

(i) *Soil Health and Fertility* focussed on 'phosphorus'. Events like the Sustainable Phosphorus Summit (SPS8 in Ghana, 30 September to 03 October 2025) dwelt on sustainable phosphorus use in agriculture, food security, and the environment, and aimed to build an African Sustainable Phosphorus Network (ASPN) for better management (See Manzeke-Kangara et al., 2025).

(ii) *Assessment of Toxic Metal (TM) Pollution* was carried out on soils, crops, and water from fertilizers, wastewater, and mining. Risks to human health were evaluated using modelling and advanced speciation techniques (XAS). Advanced X-ray Absorption Spectroscopy (XAS) techniques using synchrotron light provided

element-specific insights into the oxidation state, coordination, and local structure of elements in complex samples.

(iii) *Nutrient Cycling*: Studies investigate the effect of rainfall, weathering and land use on nutrient (major ions, trace elements, REEs) distribution and crop uptake in various watersheds.

(iv) *Precision Agriculture*: Using V-NIR spectroscopy and advanced methods to characterise soil properties for better fertilizer/amendment decisions.

(v) *Elemental Tracing*: Using Rare Earth Elements (REEs) as tracers for soil processes and pollution.

(vi) *Molecular Speciation*: Understanding metal forms in soil using synchrotron techniques (XAS) to predict bioavailability and toxicity.

(vii) *Integrated Hydrogeochemistry*: Linking soil, rock, and water chemistry to understand nutrient generation and depletion in agricultural areas (See, e.g., Jokam Nenkam et al., 2022; Kpiebaya et al., 2025).

(viii) *Geochemical Modelling*: Applying chemometrics to understand groundwater quality and pollution sources (geogenic/anthropogenic) affecting agriculture.

(ix) *Climate-Smart Agriculture*: Integrating geochemical understanding to mitigate climate impacts on soil nutrients and productivity.

5. CHEMISTRY OF AIR POLLUTION

Activities related to the chemistry of air pollution in Africa for 2024 and 2025 were centred around capacity building (WMO training), leveraging global policy (UNEA-6), scientific conferences, intensive research into sources (Nigeria, South Africa, Egypt) and health impacts [PM_{2.5}, hazardous air pollutants (HAP)], and implementing solutions like clean cooking fuels, better monitoring (satellites, low-cost sensors), green innovation technologies to reduce carbon and PM_{2.5} emissions, particularly in industries like cement production, steel manufacturing, and petrochemical plants which are major sources of pollutants in Africa, and enhanced data integration for policy action against rising heat and pollution risks. Key themes involve addressing indoor and outdoor sources, integrating health data, and establishing strong regional policies for sustainable development.

A detailed listing of the key activities and themes (2024 - 2025) runs as follows:

- *Policy and Governance*: The UNEA-6 Resolution (2024) landmark UN resolution acknowledged air quality challenges in Africa, boosting efforts like the Africa Clean Air Program (SEI). The WHO Global Conference (March 2024) and Roadmaps: Renewed commitments for 50% reduction in air pollution health impacts by 2040, updated global strategies.

- **Research and Data:**

(i) *Source Apportionment*: Studies identified key pollutants from vehicles, industry (artisanal refining), dust (Cairo), and biomass burning (Nigeria, SA). Other studies examine the chemistry of specific pollutants, such as polychlorinated naphthalenes (PCNs) in Southern and West Africa, identifying sources like open waste burning and industrial emissions; and the health impacts of fine particulate matter (PM_{2.5}) in West Africa, e.g., in Nigeria.

(ii) *Health Impact Studies*: Focus on PM_{2.5} effects on children (Nigeria) and integration of electronic health records.

(iii) *Monitoring*: Calls for better spatio-temporal trends using satellites, high-quality monitors, and low-cost sensors, especially in under-monitored areas like Nigeria.

- **Capacity Building and Training:**

During September 2024 the World Meteorological Organisation (WMO) organised a number of Training Webinars on air quality prediction and modelling for Africa, covering processes, models, and observation.

- **Solutions and Interventions:**

(i) *Clean Cooking*: Promoting cleaner fuels to reduce Household Air Pollution (HAP).

(ii) *Green Infrastructure*: Planting trees, green roofs to cool cities and filter air (Kigali example).

(iii) *Data Integration*: Using advanced techniques to link pollution data with health outcomes and policy.

Key Challenges and Future Focus (2025+)

(i) *Bridging Data Gaps*: Fragmented monitoring needs systematic expansion.

(ii) *Toxic Elements*: Addressing persistent toxic chemical pollution in water, soil, and food chains.

(iii) *Climate-Health Nexus*: Understanding how rising heatwaves intensify pollution risks.

(iv) *Policy Implementation*: Translating global commitments into effective national policies, especially for industrial/agricultural emissions.

Key Conferences and Events

Several major conferences and workshops in 2024 - 2025 addressed air quality challenges and solutions in Africa:

(v) The sixth session of the United Nations Environment Assembly (UNEA-6) took place from 26 February to 01 March 2024 at the United Nations Environment Programme (UNEP) headquarters in Nairobi, Kenya. UNEA-6 concluded with the adoption of 15 resolutions to advance collaborative action on the triple planetary crisis of climate change, nature and biodiversity loss, and pollution and waste.

(iv) African Union Summit: The 38th AU Summit held in Addis Ababa, Ethiopia from 15 - 16 February 2025 saw the adoption of critical strategies for clean and sustainable energy and transport pathways, including the African Green Hydrogen Strategy and the African Energy Efficiency Strategy and Action Plan.

(i) CLEAN-Air Forum 2025: The third annual forum was held in Nairobi, Kenya, from July 15 - 17, 2025, under the theme "Partnerships for Clean Air Solutions". It served as a key platform for knowledge sharing and collaboration on air pollution in African cities.

(iii) ESG and Climate Africa Summit: This summit held from 26 to 27 November 2025 in Nairobi, Kenya featured discussions on integrating environmental, social, and governance principles, including climate change mitigation and renewable energy sources, to promote sustainable development.

(ii) African Society for Air Quality (ASAQ) Annual Seminar: This seminar was held online from 03 to 04 December 2025 and brought together scientists to discuss air quality research, including topics like pollutants and sources, monitoring advances, and health impacts.

6. CHEMISTRY OF SOIL POLLUTION

Activities in African soil pollution chemistry (2024 to 2025) focussed on the identification of sources (mining, waste, agriculture), analysing contaminants (toxic metals, hydrocarbons, pesticides) using advanced techniques, assessing risks to health and environment. Development of sustainable remediation (phytoremediation, bioremediation) and policy solutions featured prominently in addressing the issues. Ongoing research by universities (in Ghana, Nigeria, Kenya) and organisations (AU, UNEP) tackle issues ranging from urban dumps to agricultural runoff; and the development of sustainable policies to manage major pollutants like toxic metals and hydrocarbons.

Key Themes and Activities (2024 - 2025) include:

(i) *Assessment and Mapping*: Field surveys, remote sensing, and GIS were used to map polluted sites, especially around industrial zones, mining areas, and intensive farms.

(ii) *Contaminant Characterisation*: Detailed chemical analyses (AAS, ICP-MS, GC-MS) were employed to identify specific toxic metals (Pb, Cd, As), PAHs, pesticides, and emerging contaminants.

(iii) *Health and Ecological Risk*: Studies linking soil pollution to human health (food chain), water contamination, and ecosystem health were widely conducted.

(iv) *Remediation Technologies*: Developing and testing cost-effective, context-specific solutions like using local plants (phytoremediation) or microbes (bioremediation).

(v) *Policy and Management*: Advocating for better waste management (4Rs: Reduce, Reuse, Recycle, Restore), stricter industrial regulations, and sustainable agriculture practices.

Examples of Research Focus Areas in Africa:

- *Mapping Initiatives*: Numerous studies are underway to map pollution hotspots and assess ecological and human health risks.

- *Southern Africa (South Africa, Zambia)*: Mining legacy sites, toxic metals and coal ash contamination.

- *West Africa (Nigeria, Ghana)*: Artisanal mining (Hg, Pb), e-waste, oil spills (hydrocarbons). Researchers are also conducting extensive soil sampling and analysis in areas impacted by artisanal gold mining in the Sudan.

- *East Africa (Kenya, Ethiopia)*: Agricultural runoff (pesticides), urban plastic pollution and industrial zones.

- Advanced techniques, including machine learning (ML) are being used to identify the sources and distribution of toxic elements in Nigeria and Ghana (See, e.g., Kwayisi et al., 2024; Kazapoe et al., 2025).

- *Remediation Research Projects and Green Initiatives*: Implementation of cleanup efforts often involving “green remediation” (GR) or “sustainable remediation” (GSR) practices aim to minimise the environmental footprint of the cleanup process itself (See. Otunola et al., 2025). Large-scale initiatives like the ongoing clean-up in the Niger Delta of Nigeria and the multi-national Great Green Wall Initiative to combat desertification and land degradation in the Sahel region, are major focal points for land restoration. Some African governments have begun enforcing financial guarantees from mining companies in 2024 to ensure funds are available for post-operation site rehabilitation.

- A significant research need is the development of a comprehensive, continent-wide soil information system (SIS) for effective monitoring and data sharing (See Kome et al., 2025).

Conferences and Knowledge Sharing: Academic and professional bodies are organising events which collectively aim to address the significant challenges posed by increasing waste generation and disposal and industrial expansion on soil health across the Continent. These meetings discuss research findings and

plan future strategies on soil pollution in Africa. The 3rd International Congress on Natural Resources and Sustainable Development (RENA'2025) which took place in El Jadida, Morocco from 18 - 20 December 2025, brought together experts to discuss environmental protection and sustainable solutions.

7. GEOCHEMICAL DATA AND ANALYSIS

Key trends in geochemical data analytics in Africa during 2024 and 2025 have heavily involved the leveraging of AI and ML for critical mineral exploration (lithium, cobalt, rare earths) driven by global energy transition (See, e.g., Davies et al., 2025; Fu et al., 2025), alongside vital groundwater quality and environmental health studies for sustainability. These activities have integrated analytical techniques such as XRF, ICP-MS, and remote sensing to map anomalies and guide resource development, with a push for better data generation and policy frameworks to support mineral development.

Integration with Policy and Climate Resilience

Geoscience data are increasingly being used to inform strategies for sustainable development, climate change mitigation, and infrastructure planning. This involves developing geological models to facilitate geothermal energy development and subsurface CO₂ storage, aligning with global initiatives like the Africa Water Vision and the UN's Sustainable Development Goals (SDG 6).

Regional Examples and Drivers

- Nigeria: Focus on natural hydrogen potential, leveraging gas infrastructure, with studies highlighting data gaps.
- South Africa/DRC: Continued leadership in mineral production, with efforts to move beyond extraction to value addition.
- Broader Africa: Driven by initiatives like the [Africa Mining Vision](#) and partnerships (EU/US) for secure mineral supply chains, addressing underinvestment in geoscience.

Conferences and Workshops (2024 - 2025)

Several events are bringing together geoscientists to share findings and methodologies:

- Marine Data 4 Africa Workshop: Hosted by the Copernicus Marine Service, this Workshop was held from 03 - 05 March 2025 and explored key coastal and oceanographic phenomena across the eastern, western, and southern coasts of Africa.
- CAG30 (30th Conference of African Geoscientists): This conference which was held from 22 to 25 September 2025 in Nairobi, covered a wide range of topics

including mineral exploration, geothermal development, and AI in geosciences in Africa.

- ISS ESGS 2025: The International Conference on Environmental, Social, Governance and Sustainability (ISS ESGS 2025) was held from 15 - 19 December 2025 in Cape Town, South Africa focussed on environmental, social, governance, and sustainability issues within the resource sector, highlighting a dynamic field increasingly focussed on sustainable resource management and leveraging innovative data science techniques.

8. MARINE GEOCHEMISTRY

Major activities in marine geochemistry in Africa for 2024 and 2025 involve international events such as conferences, training schools, research initiatives under the UN Ocean Decade, and published studies on the geochemistry of African coastal regions and ocean floor.

(i) Marine Data 4 Africa 2025 (Copernicus/Africa), a two-day workshop held from 03 to 05 March 2025 to explore Africa marine data, covering currents, waves, and geochemical aspects across coasts, featuring topics like kelp geochemistry in Namibia and cyclone impacts in Mozambique.

(ii) The GEOTRACES Summer School held in Cape Town, South Africa from 17 to 21 November 2025 is a major international training event for PhD and early career researchers on marine biogeochemistry, focusing on trace elements and isotopes, covering global cycles with regional applications, fostering collaboration, and launching the new GEOTRACES data product, and (iii) The BGP Oceans Empowering Nigeria, an intensive training which took place in Lagos, Nigeria in 11 and 12 December 2024 on marine fauna monitoring, part of the Ocean Decade initiatives.

Research Focus Areas in Marine Geochemistry during 2024 to 2025 include:

(i) Coastal Dynamic - Studying upwelling in the Gulf of Guinea and heatwaves in the Agulhas Current. (ii) Establishing geochemical baselines for marine ecosystems (e.g., Namibian kelp); (iii) Impact studies such as assessing the effects of tropical cyclones (like Chido in 2024) on marine environments and sustainable aquaculture, rising satellite data for development.

Several research papers published between 2024 and 2025 focussed on marine and environmental geochemistry in specific African regions, e.g., studies on the distribution and ecological risk of toxic metals in river sediments on the Atlantic Coast of Cameroon and Nigeria (See Tiabou et al., 2024); research on the geochemical behaviour and provenance of surface sediments off the coast of Sierra Leone (Hu et al., 2024) and investigations into the geochemistry of Late Cretaceous to Paleogene sedimentary formations in the Anambra Basin, Nigeria, to understand depositional environments (Omietimi et al., 2024).

9. MAPPING FOR AFRICA GEOCHEMICAL DATABASE COMPILATION

Research efforts continued in 2024 and 2025 to develop methodologies for using existing hydrogeological and lithological data from databases to improve existing geological maps in highly weathered regions of Sub-Saharan Africa.

Specific activities related to Africa Geochemical Database (AGD) compilation in 2024 to 2025 centred around the integration of new data (Nigeria, Angola), leveraging AI/digital platforms (Global Geochemical Baselines), and creating prospectivity maps for critical minerals. Much effort was directed towards the fulfilment of other major pan-African initiatives, national geological survey projects, and international cooperation programmes. These include, capacity building and the use of advanced analysis (XRF, ICP-MS) to map elemental distributions for health, environment, and mining. Major initiatives involve the USGS with Angola, UNESCO-IGCP, and national geological surveys, expanding digital tools like the Digital Chemical Earth platform for continental-scale resource assessment.

A detailed listing of primary activities relevant to the AGD compilation during the 2024 to 2025 period runs as follows:

- (i) Angola Mineral Resource Assessment: The USGS established an MOU with the Angola Geological Institute (IGEO) in November 2023 focusing on scientific cooperation, geological mapping, and assessing Angola's critical mineral potential (like rare earths) to attract investment, aligning with Angola's mining diversification beyond diamonds.
- (ii) African Union (AU) Strategy Implementation: Following the African Forum on Mining in March 2025, the AU reinforced the importance of reliable geological data. Activities under the overarching Africa Green Minerals Strategy involve: Strengthening national and regional geoscientific institutions to expand geological mapping and mineral resource assessments; and the development of a robust geological and mineral information systems to support the African Mining Vision and attract investment. The full strategy document is available from the [African Union](#).
- (iii) Pan-African Efforts: Initiatives under Earth Observations (GEO), the PanAfGeo+ Programme focusses on global baseline networks and data sharing. The third phase of this Project (PanAfGeo+) commenced in 2024 and is expected to run till 2029. Activities focus on: (1) Integrating new themes such as geospatial data and digital transformation. (2) Strengthening the capacity of African geoscientific institutions through training in geoscientific information management, and (3) Consolidating the network of European and African geological surveys to enhance data sharing and management protocols.

(iv) Nigeria: Ongoing studies use stream sediments for baseline data, mapping contamination, and identifying mineral potential in West Africa. The Nigeria Geological Survey Agency (NGSA) indicated specific areas for proposed geochemical data acquisition in its 2024 plans, often in collaboration with international partners.

(v) Geochemical exploration in Cameroon: A study on stream sediment geochemistry in Cameroon was conducted to explore base metals and assess pollution risks in aquatic ecosystems.

Main applications of a complete AGD

(i) Mineral Exploration: Identifying new deposits (base metals, REEs, precious metals).

(ii) Environmental Health: Baseline mapping for urban contamination, agriculture, and health assessments.

Methods and Technologies

(i) Sampling: Stream sediments, soils, rocks, water.

(ii) Analysis: ICP-MS, XRF, AAS for elemental analysis.

(iii) Mapping: GIS, geochemical anomaly delineation, multivariate statistics.

Key Output

(i) Digital geochemical atlases; (i) prospectivity maps; (iii) datasets for resource assessment and as motivation for inauguration of new infrastructure and projects, e.g., the Namibia Geochemistry Laboratory. In September 2025, a new geochemistry laboratory was launched in Walvis Bay, Namibia, to provide analytical services for the mining industry. Despite the apparent successes experienced during the period under review (2024 to 2025) many of the challenges in the AGD compilation remain (See Davies, 2025).

10. GEOCHEMISTRY IN MINERAL (ORE) EXPLORATION AND IDENTIFICATION

African mineral exploration geochemistry moved towards high-technology, data-intensive methods to efficiently find critical minerals, supported by national strategies and increasing private sector interest driven by global energy shifts. Key activities during the period 2024 - 2025 include detailed geochemical mapping [not necessarily within the AGD guidelines (Darnley et al., 1995)], identification of hydrothermal systems, and integration of diverse data streams (geophysics, remote sensing) to de-risk exploration for investors, particularly for battery minerals and base metals. The period saw a significant trend toward using geochemical data to identify areas with high potential for critical minerals like Rare

Earth Elements (REE), Tantalum (Ta), Niobium (Nb), Uranium (U), and Platinum (Pt).

Techniques such as X-ray Fluorescence (XRF) spectrometry were leveraged for rapid elemental analysis, utilising big data for better targeting. Isotope (Pb, Se) geochemistry and water analyses were applied, and novel methods explored for critical minerals (Li, Ni, Co), with major government investment in Nigeria and a continental push for data-driven discovery driven by energy transition demand.

Advanced analytical techniques engendering multivariate statistical processing, such as principal component analysis (PCA) are now used to interpret large geochemical datasets, which helps in identifying lithogeochemical signatures and mapping bedrock geology even under lateritic cover. Geochemical analysis is focussing on "pathfinder" elements associated with mineralisation, such as As, Sb, Cu, Bi, and Co to predict the location of gold deposits.

Deep seabed mineral resources exploration was also well underway during 2024 and 2025. The International Seabed Authority (ISA) held seminars and released reports in 2024 - 2025 discussing the challenges and opportunities for collaborative research on mineral resources in the South and Equatorial Atlantic Ocean, which involves extensive marine scientific research and geochemical analysis.

Countries such as Côte d'Ivoire, the Democratic Republic of the Congo (DRC) and Zambia are exploring for Li, Co, Ni, Au and other metals, using geochemical mapping and advanced techniques. Studies in Nigeria are using stream sediment and soil geochemistry to locate gold mineralisation and associated elements, and to map bedrock lithologies for exploration purposes (See, e.g., Ngozi-Chika et al., 2025). Studies focus on Au, base metals (Cu, Pb) in areas like Zamfara using XRF for deposit delineation, and lithium extraction methods.

Geochemical mapping in west-central Nigeria has identified placer deposits with potential for Au, REE, Ta, Nb, U, and Pt, and has helped identify areas of anthropogenic contamination. Research on groundwater in Nigeria has used geochemical data to understand the sources of dissolved solids and the influence of factors like fertilizer use on water chemistry (Jolaosho et al., 2024).

Integrated Surveys for Gold: Integrated geological, geophysical, and geochemical surveys were conducted in north-central Nigeria's schist belts (e.g., Owu and Zamfara) to characterize and identify gold mineralisation using techniques like ICP-OES and fire assay on rock and soil samples. Geochemical studies also in Nigeria, emphasised the value of using modern techniques like X-ray fluorescence (XRF) for rapid elemental analysis and applying remote sensing imagery with specific band ratios to map alteration minerals related to different ore types, such as hematite and magnetite deposits in Kogi State.

Research published in 2024 and 2025 highlights several active areas of geochemical exploration across Africa, particularly in Nigeria and Zambia:

Lithium Exploration in Nigeria: There was a notable escalation in the exploration and extraction of lithium ore activities in Nigeria during 2024 due to high global demand for electric vehicle battery materials.

Research explored the use of hydrogeochemistry as an effective tool for detecting deeply emplaced mineral occurrences. A case study examined the application in exploring Iron Oxide Copper Gold (IOCG) deposits in the Kitumba district of west-central Zambia.

Research in the Central African Copperbelt is exploring the potential of using phytogeochemistry (geochemistry of plants) as a technique for mineral exploration. Research is being published on the organic geochemistry of various Nigerian frontier basins, assessing their potential for oil and gas generation. The African Energy Chamber's 2025 outlook also discusses high-impact drilling and the potential of African hydrocarbon basins.

Groundwater and stream water are being assessed for mineral signatures. The use of field portable tools is gaining prominence in multielement analysis for immediate results.

Government investment and policy is exemplified by Nigeria which is allocating significant funds (approximately US \$630M) for exploration to generate quality data, aligning with the African Union's (AU's) Africa Mining Vision (AMV). "The African Union's (AU) Africa Mining Vision (AMV), adopted in 2009, is a strategic framework to transform Africa's mineral wealth from a curse into a driver for inclusive, sustainable development by ensuring transparent, equitable, and optimal exploitation for broad-based growth, integrating mining into local economies, and creating robust value chains."

Future-oriented research lies in investigating metal mobility, survival of indicator minerals, and improving interpretation software (GIS).

In the broader African context the aim of applying regional geochemical surveys is to identify unseen deposits, leveraging the support of national geological surveys, and meeting critical mineral demands. In this pursuit, a number of challenges remain, chiefly, the lack of quality geological data which hinders private investment; the need for more trained exploration geochemists and integrating big data analytics with new geochemical data generation.

Several specific courses and conferences related to geochemistry in mineral exploration took place in Africa during 2024 and 2025. Additionally, numerous research and exploration projects utilising advanced geochemical techniques were active across the continent.

Specific professional development opportunities, courses and conferences in Africa during 2024 - 2025:

(i) Geochemical Exploration: Methods and Analysis of Data (Short Course): This 5-day classroom and field course, led by Yann Itard (in French), was held during 13 - 17 October 2025, in Saly, Senegal as part of the Agate Project training initiatives.

(ii) Professional Training Course (Agate Project): A separate session of professional training course was held in Nairobi, Kenya, from September 29 to October 3, 2025.

(iii) The 3rd International Congress on Natural Resources and Sustainable Development (RENA'2025): This congress was held at Chouaib Doukkali University in El Jadida, Morocco, in December 2025.

(iv) SASUF (South Africa-Sweden University Forum) Satellite Events (Online/Hybrid): A specific event held during 13 - 14 May 2024 focussed on "Critical Raw materials (Mineral to Metals): Challenges and Opportunities", bridging South Africa and Sweden in research and innovation.

11. URBAN GEOCHEMISTRY

Urban geochemistry activities in Africa (2024 - 2025) focussed on toxic metal pollution, soil health, and geochemical mapping for developing baseline data for understanding element distribution, crucial for environmental management and land use planning. Urban studies on human health linked geochemical findings to public health impacts, especially for vulnerable populations; and addressing challenges unique to African megacities.

Research and publications focussed on toxic metal contamination and environmental health risks. Examples of research include studies on road dust in Cairo, which assessed toxic metals, contamination levels (using Igeo, EF), and calculate carcinogenic risks for children and adults (See, e.g., Mostafa et al., 2024).

Major urban planning initiatives and conferences highlighted challenges (funding, data) and advocated for collaborations in African urban geochemistry. Key events like the SEGH conference in Nigeria (01 - 04 July 2024) and PanAfGeo training in Dakar, Senegal, from 01 - 12 July 2024 addressed critical challenges such as land degradation, public health risks, and the need for better data, especially in megacities such as Cairo, linking local studies to global sustainability goals. Sustainable development initiatives integrated urban geochemistry into broader goals concerning climate change, biogeochemical cycles, and ecosystem health. Other major conferences and events include:

(i) "Africa's Urbanisation Dynamics 2025 Report" Launch: The OECD, AfDB, Cities Alliance, and UCLG Africa launched a major report and hosted associated webinars on 06 March 2025. While focussing on urban planning and policy, this initiative provided the foundational data for future urban geochemistry studies regarding sustainable city expansion, infrastructure, and resource management; (ii) 3rd International Congress on Natural Resources and Sustainable Development (RENA'2025) took place in December 2025 in El Jadida, Morocco, with the aim of fostering collaboration on environmental challenges and sustainable solutions, including resource management; (iii) The World Environment Expo Kenya was held in Nairobi on 16 to 17 December 2025, focussing on the environmental protection industry in Africa, renewable energy, and sustainable practices.

Future perspectives include increased collaboration between academia, research centres and governments, addressing data gaps and promoting multidisciplinary projects in urban areas and integrating urban geochemistry into global discussions on climate change and environmental health. Development of scientific frameworks emphasised understanding of sources, transport, and fate of chemicals in cities in order to inform future research.

12. ANALYTICAL GEOCHEMISTRY

During 2024 and 2025, the application of modern Analytical Geochemistry methods continued to be hampered by a shortage of highly skilled personnel and accessible modern analytical technology. Analytical work during the period under review focussed heavily on the critical minerals, assessing the extent of their potential for the energy transition (lithium, cobalt, etc.) and for driving advanced exploration. These analyses highlighted skill gaps but also leveraged new technologies (AI/ML in data, automation) in tackling environmental issues like Acid Mine Drainage (AMD) using modern analytical methods like ICP-MS, XRF, and isotope analysis, with conferences and new projects emerging in Nigeria, Kenya, South Africa, and beyond.

Key events and projects (2024 - 2025) include the aforementioned geochemistry laboratory expansion by SGS which has launched a new geochemistry laboratory for the mining industry in Namibia and are expanding services in South Africa.

Several key conferences and short courses related to analytical geochemistry took place in Africa during the 2024 - 2025 period, organised by professional bodies like the Pan Africa Chemistry Network (PACN) Congress (29 to 31 October 2024, Nairobi, Kenya) and the 45th National Convention of the South African Chemical Institute (SACI-45) 2025 (30 November to 05 December 2025) held in Johannesburg, South Africa. The African Minerals and Geosciences Centre (AMGC) regularly offer a range of training services in the mineral industry,

including courses on specific analytical techniques (e.g., spectrometric analysis, gold analysis, quality control) and field methods like GIS and sampling.

13. GEOCHEMISTRY IN WASTE MANAGEMENT [INCLUDING WASTEWATER TREATMENT (AMD)]

During 2024 and 2025 in Africa, geochemistry in waste management, especially in the realm of Acid Mine Drainage (AMD) and wastewater, focussed on sustainable, integrated solutions, using municipal wastewater byproducts (*struvite*) for AMD treatment, exploring bioremediation, passive systems (PRBs), and novel materials, integrating resource recovery (metals, minerals, water) with treatment (like HiPRO®/DESALX®); and reducing carbon footprints through life cycle assessments, with South Africa leading research in these green tech advancements. Studies on advanced membrane technologies (RO for mine wastewaters) and improved monitoring to control metal leaching and contaminants, are driving innovation in sludge reuse, water recovery, and circular economy principles to address vast needs (See, e.g., Omohwovo, 2024).

14. EXTRATERRESTRIAL GEOCHEMISTRY

During 2024 - 2025, African extraterrestrial geochemistry and astrochemistry activities were centred around the leveraging of Earth Observation (EO) for terrestrial challenges (water and food security), building capacity [European Space Agency (ESA) Fellowships, African Academy of Sciences (AfAS) events], and exploring extreme environments as Mars analogues (Nigeria, Namibia) for future life-detection. Other major initiatives like ESA's EO Africa R&D calls and UNESCO geoscience projects drove collaboration and elicited funding for African-led research into space resources and fundamental astrochemistry.

15. ISOTOPE GEOCHEMISTRY, INORGANIC- AND BIOGEOCHEMICAL PROCESSES

During 2024-2025, notable African research projects that leverage isotope tools include those for critically addressing environmental challenges. These projects were supported by a fitting regional infrastructure and aligned with global shifts towards sustainable inorganic and biogeochemical research. Major research projects on isotope geochemistry and biogeochemistry such as the BIOGRIP initiative [<https://www.biogrip.ac.za/about-biogrip> (Accessed 19.12.2025)], featured huge components on water security, mineral interactions and mining impacts [University of Cape Town, University of Stellenbosch, University of the Free State and North West University, all in South Africa), and linked environmental isotopes ($\delta^{18}\text{O}$, $\delta^2\text{H}$) to seasonal hydrology in diverse regions like Cameroon, revealing rapid wet season recharge and dry season evaporation. Central themes include monitoring natural/anthropogenic inputs, water-mineral-microbe interactions, and advancing green chemistry in inorganic processes, driven by African research platforms and global trends in chemical research for sustainable development.

CONCLUSION

In essence, 2024 - 2025 saw Africa's Applied geochemistry sector predominated by activities centred around the geochemical circulation of nutritional and potentially toxic elements in the water, soil and air environment in the context of environmental health and disease causation through diet. The period under review also witnessed modernisation of the tools of Applied Geochemistry, focussing on data-intensive, technologically advanced methods to unlock strategic minerals and secure water resources for sustainable development, moving from basic analysis to predictive modelling and AI-driven exploration.

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