



A REVIEW ON ENVIRONMENTAL RESEARCH

Sunday Ayoola Oke

*Dept of Mechanical Engineering, University of Lagos, Akoka-Yaba, Lagos, Nigeria
tel: (234-01) 4938637-9 Ext. 1114, E-mail: sa_oke@yahoo.com*

Received 17 Feb 2004; accepted 28 May 2004

Abstract. Environmental research has recently attracted much attention in the scientific and engineering communities. The resounding theme in the literature is an emphasis on achieving a globally friendly environment while the environment is preserved and its quality improved upon. Attaining a high level of health status has also been the primary concern of its stakeholders. New technologies are continuing to emerge, thereby stimulating mutual research interaction among the scientific and technical communities on all the six continents. The inter-disciplinary problems posed by natural and human-induced changes in the earth's environment has therefore been the concern of many investigators in ecology, geography, civil engineering, marine engineering, biology, chemistry, earth science and physics, among others. Yet, there is a gap in the body of knowledge on environmental research. The popular and scholarly literature is deficient in studies that reflect the past, present and future trends of research in the field. This paper provides a comprehensive review of the field. The review covers general surveys, models, empirical studies and cases of original research in the field. Studies considered are those that have contributed significantly to knowledge. The review raises a new challenge and predicts growth areas in the next several decades.

Keywords: environment, review, environmental science, environmental engineering, pollution, contamination.

1. Introduction

During the last thirty years and much more in the last decade, the manufacturing and service industries have progressively expanded human activities. Consequently, this has resulted into a heightened market competition and the need for customer satisfaction that gradually increased the sensitivity of companies, and has prompted them to produce high quality products and services with modern technologies. These modern technologies, although have brought about radical changes in productivity, have their attendant problems, thus imposing environmental threats on our environments.

Much research documentation and development is still being done on the methods for controlling these imposed environmental threats, and the global warming problem with its countermeasure technologies. The literature has called for the need to direct efforts to the complex environmental problems around us. More recently, researchers have argued that for nations to stay healthy, the environment must be well understood. Today, environmental problems present a big challenge to most governments in developing countries. Consequently, there is a huge investment of human intelligence and

capital resources in the management and control of environmental problems. There is need to recognise that the earth is finite that makes our activities subject to the various limitations imposed by the overall global system.

Research on developmental activities on the environment has led us to understand the steadily increased commitment of governments and multinational corporations to environmental protection. These stakeholders have introduced internationally accepted ISO quality standards, which are more stringent than legally mandated regulations. Primarily this joint effort aims at: (1) reducing the burden on the environment thus forcing many companies to introduce energy saving facilities at their plants to help reduce carbondioxide emissions and prevent global warming. Some organisations have lowered their carbondioxide emissions by converting fuel oil to natural gas as a boiler fuel. (2) lowering generation of waste products, promote recycling and increase environmental friendliness of manufacturing processes. (3) attaining international certification of environmental management systems, and (4) disclosing environmental information.

In spite of the advances made on the scientific front and with the realisation that we are in a wonderful age of discovery about issues in environmental research, unfortunately little comparison and integration across studies exist. Certainly, we are lost in a *Tower of Babel*, where we do not understand what others who are building this structure with us are talking about. And so, in this paper, we have set out to create a common understanding of environmental research based on the work of key scholars.

The goal of this paper has been to advance and sharpen our understanding of environmental research. It is also important for us to be clear about what our purpose is not. We are not attempting to provide an all-encompassing framework on the literature on environmental research. Rather, an attempt is made to provide a starting point for integrating research in this domain and suggest avenues of future research. The study involves an exploration into various disciplines of ecology, geography, civil engineering, marine engineering, biology, chemistry, earth science and physics, among others. With this study, we have reflected the past, present and future trends of research in the field.

2. Historical overview

The environmental literature has a wide area that naturally divides into three: science, engineering, and law. Extensive research has been carried out in all these major areas. As such, the high rate of proliferation of research articles may be difficult to track. Possibly, on a yearly basis, a new journal springs up or several tenths of conferences, workshops, and symposia are held on the environment.

Clearly, applications of the principles of economics, statistics, mathematics, and computer science are some of those that continually expand the frontier of knowledge in environmental science and engineering. It could be inferred that environmental literature has matured to the extent that interdisciplinary research is much easier than in some major science or engineering based fields. Today, experts on environment are found in all the six continents of the world with diversities of specialisation.

In tracing the history of environmental research, the honour of initiating research in environment probably belongs to the environmental scientists in the chemical and biological areas of science. Although, some environmental studies in science may have begun a long time ago, they were probably not noticed.

However, prominent research streams were identified in the 1960's with hosts of scientists featuring in the game. The bulk of science researchers were primarily ecologists, ecotoxicologist, environmental chemists, environment health specialists, environmental regulators, biologists, hydrologists, geographers, earth scientists, marine scientists, and atmospheric scientists. Researchers sought to quantify the impacts of contaminants in

the human environment, and to address human impacts on the natural environment itself.

Soon after, in recognition that scientific issues related to environmental health and human welfare were important, the entire spectrum of sources, pathways, sinks, and interactions between environmental pollutants, in chemical, biological, and physical aspects of the environment were explored. Some other themes within the field of environmental science, such as those related to environmental risks and hazards, waste disposal and the modeling of environmental impacts were also part of the principal investigations.

After the 1960's, the engineering wing of environmental research sprang up with a gradually increasing interest of engineers in environmental research. Scholars in civil, chemical, marine, and mechanical engineering dominated the research scene. The area offers broad multi-disciplinary information and attracted a stream of mathematically inclined investigators with strong affinity for modelling and simulation. From this period, environmental research had a new outlook where research collaboration existed across the globe.

The focus of most research was on design, development of engineering methods, management, and government policies. Most of the research skewed towards the societal impact of wastewater collection and treatment, transport of contaminant on watersheds in surface water, ground water, and soil. Atmospheric studies as related to control and treatment of hazardous waste and the design and management of solid waste facilities were also explored. All these investigations were made from engineering perspective.

In the 1970's, attention was given to environmental law. The goal was to provide a valuable explosion of the legal framework surrounding the environment. The focus of investigations was on governments, environmental groups and trade organisations, among others. The issue raised relates to the general environmental threats caused by manufacturing industries to the communities.

The decade 2000 promises an increased attention of professionals, scholars, and governments to environmental research. The heightened recognition of the need for an environmentally friendly global society would yield dividends in the current decade. Environmental measurement parameters would serve as basis for federal governments of various countries to control the quality of the environment. As such, a higher proliferation of the literature is expected in the environmental domain. In particular, application of emerging concepts and scientific tools such as analytical hierarchy process (AHP), Fuzzy logic, and genetic algorithm (GS) would be fully explored.

3. Literature review

The literature on environment can be broadly viewed from natural and human-induced changes in the earth's environment. Much research and development have there-

fore taking place to investigate, model and control environmental problems. Two broad research streams can be identified. The first concerns the conservation of the environment in terms of protecting and nurturing the earth's environmental living things and preserving their existence. We do not claim to review any work in this area.

The second aspect of the environmental literature concerns a study of pollution and its consequences. Clearly the literature is full of several thousands of this type of studies. A significant part of the study of pollution lies in the area of contamination. This subject has been viewed from three perspectives: soil, water and air. Researchers such as Barcon (2002), Adeniyi and colleague (2002), Sponza and Karaoglu (2001), Satsangi and other researchers (2002) have extensively studied soil contamination. Three out of four of these researchers determined soil contamination through experimental analysis. The only study that attempts to model soil contamination is by Barcon. If the sample is representative of the soil contamination literature, then, we can conclude that modelling of soil contamination has been given less than the required attention. Therefore, an increased need for extensive studies that model the behaviour of soil contamination is desired. This will offer a lot of opportunities for scientific investigations and empirical scrutiny. Possible areas that research is needed include Ni–Cu smelter system, soil interaction with petroleum hydrocarbons and heavy metals, and water-soluble ions/soil interactions (Barcon (2002), Booth et al. (2003)).

Researchers interested in investigating the contamination medium such as soil/water interface and relationship dominate the water contamination area. McQuarrie and Carlson (2003), Thomson and colleagues (2003), Booth and associates (2003), Higashino and colleagues (2003), Fischer and associates (2003), and Hussein and Terry (2002) may all be mentioned. Studies have basically considered the treatment of water/material interaction, sources of contamination, measurement of quality of water and investigation of levels of contamination (Booth and associates (2003), Fischer and colleagues (2003), Higashino and workers (2003), Hussein and Terry (2002), McQuarrie and Carlson (2003), Ramessur and Ramjeawon (2002)).

One of the most scaring event in environmental contamination is the multi-faceted problems faced by countries globally is ground water pollution. At present there is a new threat – arsenic contamination in ground water. Arsenic is a shiny, grey, brittle element possessing both metallic and non-metallic properties.

In the area of air contamination prominent studies are due to Pandey and colleagues (2002), Chau and associates (2001), Chang and associates (2002) and Chen and other workers. Many of these studies have reported exposure to air pollutant that includes nitrogen dioxide (NO₂) respiratory dust (PM10) and carbonmonoxide (CO). It seems that more modelling work and investigations about pollution control techniques has be done in

soil contamination studies than in water and air pollution investigations.

Despite the considerable research on contamination, correlation of the various contamination types with details of their relationships is missing. An acceptable methodology for carrying out analysis on samples is also missing. Beside measurement of environmental contamination by direct means, indirect approaches in assessing the quantity of contamination in living organisms may also be used (Ruelas - Inzunza and Paez-Osuna (2002)).

The economics of contamination would be a very serious threat to agriculture, human beings and other living organisms in the environment. Hardly any data related to this is available. To collect more authentic details on environmental contamination, a survey format is needed. This methodology should be ideal for most research documentation in different parts of the world. Advancement to the literature could also be attained if models that describe the economics of contamination could evolve. Such a model would encourage proliferation of articles that may create a new attractive research area for investigators.

4. ISO certification in environmental research

Widespread concern over the state of the environment and impacts of anti-environmentally friendly activities on the quality of life of people has heightened the need for high-quality detection and understanding of environmental changes. The use of ISO quality standards has therefore gained increased acceptance in the past few years as a means to provide consistent and meaningful environmental management process. ISO quality certification has primarily been applied in manufacturing facilities and operations, especially in the absence of company- or industry-specific standards.

Specifically, in 1996, the International Organisation for standardisation (ISO) formally adopted ISO 14001 as an international standard for an Environmental Management System (EMS). EMS is a tool used by companies to implement environmental management policies in their facilities. It has interrelated organisational elements that function together aimed at helping a firm manage, measure, and improve the environmental performance of its operations. Research on the ISO certification area of quality cites increased productivity, operational consistency, and a demonstration of commitment to environmental management excellence as potential benefits of implementing ISO 14001 quality standard in manufacturing facilities and operations.

Professionals, experts, and academicians in the field have criticized the use of ISO 14001 and other standards. One weakness, indicated by a pool of research is that EMSs are process-based, not performance-based. Observers argue that instances where companies and facilities have well documented processes that were followed vigorously yet produced weak environmental performance. Other observers noted that the cost of estab-

lishing, certifying and maintaining a system could be very high. Recent research documentation reveals that EMS registration and certification provide little quantifiable business value; most of the value is intangible, involving positive public relations and corporate image. However, the success of implementation of ISO 14001 quality standard by organisations lies on the stakeholders in quality. Scientifically rigorous campaign and incentives should be drawn up and implemented by governments to create effective interaction between governments and implementing organisations.

5. Conclusions and future directions

The past several years have experienced a gradual increase of research articles in environment with studies spanning across disciplines and introducing a wide range of concepts. This study reviews past documentation and current experiences in the field of environment. The motivation for writing this paper came from several sources. The first is the uneasy feeling about the seemingly little comparisons and integration across studies. There is therefore a growing need for a systematic advancement of knowledge in comparative studies. There is need also to understand what others who are building this structure with us are talking about. This is an important problem yet unsolved and the reason for our current work. While some critical issues have been raised in this paper and some tentative answers offered, there is a strong need for rigorous empirical scrutiny of the environment literature.

Quantitative techniques are needed to predict the volume of the literature. The predictive model should serve as framework for other research investigations. An analytical model that intelligently combines the multiple attributes of the situation under which the forecast is made will be a necessity. Using multiple sources of information, the model should contain important variables which include: the number and the respective years of experience of researchers engaged in environmental research, number and years of establishment of research centres doing environmental research. Others may be their rates of proliferation of research studies, the available funding, and the frequency of release of such funds.

While developing the model, confidence limits could be ascertained while the linear assumption commonly used could be relaxed to incorporate other forms of mathematical modelling. This is therefore a call for environmental researchers to collaborate with expert in mathematics and statistics in order to develop robust mathematical models having a multi-disciplinary outlook. An important test of the model should evolve from future studies. Sensitivity analysis is expected to test the degree of responsiveness of model parameter to changes, by increasing them by small amount.

One of the findings of this study is the deficiency of reliable, comprehensive, technical, and state-of-the-art software on environmental issues. A top priority re-

search is the development of environmental software that should be comprehensive, automated and useful as a management tool, consisting of important aspects of air, soil and water environmental studies. The software to be developed should be made relevant, applicable and tailored to the practical needs of user organizations. The environmental software, christened ENVIRON, should centre on the environment model structure. The development of ENVIRON computer software from both producer and consumer perspectives is essential.

The relevant dimensions of producers' perspective include accuracy, capability, features, completeness, conformance, serviceability, stability and structuredness. From a consumer perspective, the relevant dimensions include capability, communications, completeness, conformance, features, flexibility, simplicity and stability. By utilizing the ENVIRON software, the environmental monitoring group has permanent records in a database that can be manipulated to produce the environmental impact of certain occurrences. The outbreak of disease is an example. The effect of accident due to certain environmental actions and other emerging outcomes to certain environmental threats is also a good case of parameters to be monitored.

Reports can be electronically transmitted to ENVIRON database. An interesting dimension in the ENVIRON software development could be the ability for system users to access data entry screen, reports and data submission modules, through an Internet browser. An ENVIRON CD-ROM software could be enhanced and made available at a website (www.ENVIRON.model.com). It could be developed such that no special software is required and that the operator can access the system from anywhere on the Internet.

Concludingly, (1) there is a significant interest in finding reliable methodologies in environmental modelling, including monitoring and controlling technologies. (2) a global trend is seen in practice with researchers linking environment with decision-enhancing tools like analytical hierarchy process, etc. More advancement is expected in decades to come with the possible entrance of mathematicians into environmental research. Tools including linear programming and algebra are likely to feature prominently in the environment literature. (3) a high degree of dynamism can be felt in disciplines involved in environmental studies, thus breaking interdisciplinary barriers, and paving the way for the emergence of new, micro-disciplines.

References

1. Adeniyi, A. A. and Afolabi, J. A. Determination of total petroleum hydrocarbons, and heavy metals in soils within the vicinity of facilities handling refined petroleum products in Lagos metropolis, *Environment International*, 28 (1–2), 2002, p 79–82.
2. Barcon, V. Leaching of nickel and copper from soil contaminated by metallurgical dust, *Environment International*, 28 (6), 2002, p 451–456.

3. Booth, A. M.; Hagedorn, C.; Graves, A. K.; Hagedorn, S. C. and Mentz, K. H. Sources of fecal pollution in Virginia's blackwater river. *Journal of Environmental Engineering*, 129 (6), 2003, p 547–552.
4. Chau, C. K.; Tu, E. Y.; Chan, D. W. T. and Burnett, J. Estimating the total exposure of air pollutants for different pollution age groups in Hong Kong. *Environment International*, 27 (8), 2001, p 617–630.
5. Chang, I.; Clech, P. L.; Jefferson, B. and Judd, S. Membrane fouling in membrane bioreactors for wastewater treatment. *Journal of Environmental Engineering*, 128(11), 2002, p 1018–1029.
6. Fischer, D.; Charles, E. G. and Baehr, A. L. Effects of storm water infiltration on quality of groundwater beneath retention and detention basins. *Journal of Environmental Engineering*, 129 (5), 2003, p 464–471.
7. Higashino, M.; Stefan, H. G. and Gantzer, C. J. Periodic diffusional mass transfer near sediment/water interface: theory. *Journal of Environmental Engineering*, 129 (5), 2003, p 447–455.
8. Hussein, H. S. and Terry, N. Phytomonitoring the unique colonization of oil-contaminated saline environment by *Limoniastrum monopetalum* (L) Boiss in Egypt, *Environment International*, 28 (2), 2002, p 127–135.
9. McQuarrie, J. P. and Carlson, K. Secondary benefits of aquifer storage and recovery: disinfections by-product control. *Journal of Environmental Engineering*, 129(5), 2003, p 412–418.
10. Pandey, P. K.; Yadavs; Nair S. and Bhui, A. Arsenic contamination of the environment: A new perspective from central-east India. *Environment International*, 28 (4), 2002, p 235–245.
11. Ruelas-Inzunza and Paez-Osuna F. Distribution of Cd, Cu, Fe, Mn, Pb and Zn in selected tissues of whales. *Environment International*, 28 (4), 2002, p 325–329.
12. Satsangi, G. S.; Lakhani, A.; Khare, P.; Singh, S. P.; Kumari, K. M. and Srivastava, S. S. Measurements of major ion concentration in settled coarse particles and aerosols at a semiarid rural site in India. *Environment International*, 28 (2), 2002, p 1–7.
13. Sponza, D. and Karaoglu, N. Environmental geo-chemistry and pollution studies of Aliaga metal industry district. *Environment International*, 27 (7), 2001, p 541–553.
14. Thomson, B. M.; Smith, C. L.; Busch, R. D.; Siegel, M. D. and Baldwin, C. Removal of metals and radionuclides using apatite and other natural sorbents. *Journal of Environmental Engineering*, 129(6), 2003, p 492–499.

APLINKOSAUGINIŲ TYRIMŲ APŽVALGA

S. A. Oke

S a n t r a u k a

Pastaruoju metu aplinkosauginiais tyrimais domisi mokslininkai ir inžinieriai. Literatūroje akcentuojama, kad pasaulyje aplinka turi būti saugoma globaliai bei gerinama jos kokybė. Tai įgyvendinti padeda aukšto lygio laimėjimai medicinoje, plėtojamos naujos technologijos, skatinančios mokslinius techninius tyrimus šešiuose pasaulio kontinentuose. Tarptautinė problema, kurią sukėlė neteisėta žmogaus veikla aplinkoje, sprendžiama atliekant įvairius ekologinius, geografinius, aplinkos ir jūrų inžinerijos, biologinius, cheminius, geologinius, fizikinius ir kt. tyrimus. Atliekant mokslinius tyrimus nepakanka populiarior bei akademinės literatūros, atspindinčios praeitį, dabartį ar prognozuojančios ateitį. Šiame straipsnyje nagrinėjami aplinkosauginiai tyrimai, pateikiama bendroji situacija aprašoma modeliai, empirinės studijos bei originalių tyrimų pavyzdžiai. Apžvelgti tyrimai bus reikšmingi plėtojant šią tematiką ir ateityje. Keliami klausimai bei numanomi atsakymai į juos bus aktualūs dar keletą dešimtmečių.

Raktažodžiai: aplinkos apsauga, apžvalga, aplinkos mokslai, aplinkos inžinerija, teršalai, užterštumas.

ОБЗОР ИССЛЕДОВАНИЙ В ОБЛАСТИ ОКРУЖАЮЩЕЙ СРЕДЫ

S. A. Oke

Р е з ю м е

Исследованием окружающей среды в настоящее время интересуются ученые и инженеры. В литературе акцентируется необходимость сохранения окружающей среды и улучшения ее качества в глобальном масштабе. Добиться этого помогают крупные достижения в медицине. Развиваются новые технологии, стимулирующие научные исследования на всех шести континентах мира. Для решения междисциплинарной проблемы, вызванной нелегальной деятельностью человека, осуществляются многочисленные исследования в области экологии, географии, инженерии окружающей среды, морской инженерии, биологии, химии, геологии, физики и других. При этом популярной и академической литературы, отражающей прошлое, настоящее и будущее, недостаточно. В статье анализируются исследования в области окружающей среды, представлена общая ситуация по названной тематике, описаны модели, разработки и примеры оригинальных исследований. Для развития деятельности в названной области обзор описанных исследований, а также вопросы и ответы на них будут важны и актуальны и в будущем.

Ключевые слова: окружающая среда, обзор, наука об окружающей среде, инженерия окружающей среды, загрязнители, загрязнение.