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A Review Paper

MICROORGANISMS: NIGERIA'S MOST NEGLECTED NATURAL RESOURCES

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Abstract

In Nigeria's current development efforts, microscopic life forms, collectively termed microbes or microorganisms, have not been accorded due status as natural resources, like economic plants and livestock. This is evident from the fact that hardly any efforts have been made to conserve indigenous microorganisms by establishing microbial Culture Collections equipped with facilities similar to those of countries that have continued to harness economic potentials of microorganisms. Also, interest in commercializing indigenous microbial processes beginning with Nigeria's diverse and culturally accepted fermentations associated with production of traditional foods and beverages, seems to be minimal in Government and business establishments. The current situation is likely to limit interest towards application of microorganisms to higher levels of biotechnology such as environmental bioremediation and genetic engineering. Nigeria should endeavour to emulate Southern Africa that has attained a very high standard in harnessing the potentials of microorganisms; among other things, traditional beer production in that African region, has been commercialized to a level comparable to that of western lager beers, and at least one MIRCEN (microbiological resource centre) has been established in South Africa.

Keywords: Microbes, natural resources, microbial culture, microbiological resource centre

Introduction.

The term natural resources are commonly applied to economic plants, animals, and minerals. Thus, food plants like cotton and forestry (wood and timber) plants, livestock, poultry, fish and other aquatic food animals, non meat animals like bees, are invariably considered to be natural resources. On the mineral side, organic and inorganic solids such as coal, liquid mineral (petroleum), and natural gas, also belong to the family of natural resources. Virtually all the resources tend to have one common feature: they are obtained in raw or crude form by harvesting, capturing, mining or other means, and usually require some processing or refinement to produce consumable goods like food, meat, leather, wood/timber, diverse metals, gasoline/petrol, or raw materials for manufacturing industries. Sometimes relevant processing or refining operations generate ancillary products which may become raw material for other industries, or waste products for disposal into the environment.

The biological resources covered above are those that are traditionally

cultivated or conserved for man's nutritional, energy, housing, clothing and other routine needs. Other biological resources may be conserved for other purposes. For example, some animals, and wild life generally, are conserved as beasts of burden, and as components of biodiversity as appropriate, and all are also considered to be natural resources. Elephants, camels, donkeys etc., are beasts of burden, while lions and other carnivores, chimpanzees, monkeys, many herbivores like zebra, and other animals like snakes, crocodiles, constitute prominent components of the visible category of biodiversity, and many of them are maintained in organized zoos, or allowed to roam or live naturally in parks and gardens devoted to wild life preservation. The value of this wild life in boosting tourism potential of nations and in contributing to their foreign exchange earnings is well known in southern and eastern African countries. Additionally, many of the biological resources have been exploited in scientific and medical research. One rare type of animal called the nine-banded armadillo is being conserved for its potential utility in research on leprosy; the leprosy bacterium that cannot be cultivated in the laboratory, can be grown in the animal (which serves as a reservoir of the organism) for experimental purposes. Also, medicinal plants containing antimicrobial and anticancer agents are also important natural resources (Mader, 2007). Overall, natural resources would commonly include all biological and mineral resources that can be harnessed or utilized by nations for diverse economic benefits.

Countries and organizations collaborate with each other, on mutually beneficial terms, in exploration and development of natural resources. This happens because certain resources, especially minerals are sometimes found in locations that are deficient in economic and technical requirements for exploitation of such resources. Also, other resources, especially biologicals, can be acquired, transferred, and established in climatically hospitable places where they are not indigenous. One example is the acquisition and transfer of palm produce in the fifties or sixties from Nigeria to Malaysia where it has become a significant natural resource of appreciable economic importance.

In the foregoing paragraphs, some attempt was made to highlight the author's perception of the scope or diversity of natural resources. It is obvious that plant and animals which are higher life forms are conventionally classified and accepted as natural resources. Unfortunately, it is not easily appreciated that microscopic life forms, collectively termed microbes/ microorganisms, also belong to the same category (the biologicals) of natural resources. In consequence, microorganisms are generally neglected or ignored completely in discussions of natural resources. In reality, microscopic life forms are considerably more diverse than plants and animals, and they fall into five major categories: bacteria, fungi, algae, protozoa and viruses. Among other things, microorganisms play indispensable roles as producers and consumers in natural cycles associated with functioning of ecosystems. Their roles in decomposition and decay processes associated with environmental sanitation and soil fertility, will be appreciated by most humans. Besides, they are metabolically diverse, and many of their

metabolic products are economically important to man.

To a large extent, the above mentioned underestimation of the status of microbes as natural resources is historical. Knowledge of the existence of microbes developed barely 300-400 years ago, and within this period, methods of observing, growing, handling and preserving as well as experimenting with the organisms developed only in the last 200 years. Thus, knowledge of microbes is relatively recent compared with that of plants and animals. Louis Pasteur of France, and Robert Koch of Germany, were pioneers in developing microbiological knowledge, and during their time, much emphasis was laid on the roles played by the organisms in prevailing natural and socio-culturally important processes especially disease causation, and food fermentations that yielded breads, beers, wines and dairy products like cheeses and yogurts. It was appreciated that in traditional food and beverage fermentations, specific cultural practices that had been developed over centuries before the advent of microbiological knowledge, were unconscious manipulations of types and behaviours of relevant microorganisms to optimize their performance in appropriate processes. Research on microorganisms and microbial processes were intensified, and they have continued unabated in developed countries. It seems appropriate to state that those countries also devised some methods and avenues for enabling scientists to educate the populace on useful and hazardous activities of microorganisms. Obvious improvements in disease prevention and control, and in qualities and diversities of beers, breads, and other fermented products, were probably important evidences of the value of microbiological research in those societies. Aside from their useful roles in food fermentations, further impetus on commercial potential of microorganisms was provided by the discovery, in 1928, of penicillin, a microbial (fungal) product that has continued to impact, positively on infections disease control. Microbiological investigations have not only expanded the boundaries of life science, but also led to development of other commercial products including diverse antibiotics (outside penicillin), microbial enzymes, insecticides, organic and amino acids, and so on. Additionally, knowledge of other metabolic activities of microbes such as degradation of crude oil and minerals, have led to exploitation of appropriate organisms in services such as clearing oil spills, and mining some low grade mineral ores.

In our present era, the practice of discovering/documenting microorganisms with desirable attributes, developing them for better performance, and commercializing their product/s or activities, have become regular microbiological research activities readily funded by governments, industries or companies in developed countries. The terms biotechnology, specifically microbial biotechnology, is currently applied to studies and research involving use of microbes and their products for production of goods and services. It will be appreciated that the goods and services mentioned above are of nutritional, medical/health, agricultural and environmental importance. While traditional fermentations which are carried out in diverse cultures in pre-scientific times have been classified as first generation biotechnology,

subsequent developments fall into second and later third generation biotechnology. What can be regarded as the current climax of third generation biotechnology includes mainly genetic engineering or recombinant DNA technology. In this technology, genes (DNA) of certain microorganisms are modified by introduction of specific foreign genes, thereby equipping the modified organisms for producing substances encoded in the foreign genes. Genetic engineering bypasses natural barriers of genetic recombination. Thus, human insulin gene for example, has been introduced into the bacterium. Escherichia coli and the later organism is now used to produce human insulin for treatment of diabetics. All the advances in microbial biotechnology were made possible because due recognition had been accorded to microbes as natural resources with exploitable economic potentials, and genuine efforts were put in place for acquiring and conserving microorganisms for development and commercialization. In this regard, the importance of commercial enterprises devoted to research in exploitation of microbial technologies, and of Culture Collections which are repositories of microorganisms, in development of nations, deserves to be emphasized. All developed countries of the world in Europe and North America-where biotechnology is taken seriously, have renowned Biotechnology Companies and Microbial Culture Collections. Most of the Collections function either as independent establishments or as laboratories in institutions of learning and research, or as affiliates of national/government Departments of Health, Agriculture and Environment. Some Collections contain specialized types or categories of microbes while others are specialized Collections for industrial, agricultural, environmental, medical, or health research or services. That beneficial microbes are comparable in status with useful plants and animals, and that all of them deserve to be preserved, is obvious from the following excerpts (Anon, 1979):

"… Because of the present and potential usefulness of beneficial microorganisms, it is essential that their germplasm be preserved, just as plant germplasm is preserved in seed banks and endangered animal life is protected in various ways".

"……. Several outstanding Culture Collections of microorganisms exist today……..."

Economic benefits of developing microbial resources

Acceptance of microbes as natural resources amenable to commercial exploitation led presently developed countries to establish Companies, Institutes and Departments or Organizations for conducting research on microbes with defined or potentially useful attributes, and for developing techniques and equipments for large-scale cultivation and harvesting of microbial cells and/or microbial products. Traditional fermentations that had well known cultural acceptance, specifically those involved in making beers, wines and breads, were first upgraded by development of starter technologies. Considerable capital investment, as well as capacity building, in terms of man power development, were also involved.

The economic benefits of the above investments can be easily imagined, but will be better appreciated from the following table based on relatively old data from the United Kingdom:

UK Fermentation Industry Sales (Smith, 1985)

Industry	**Sales (£M)**
Brewing	3190
Spirit	1860
Cheese	415
Cider, wine	190
Bread	150
Antibiotics	100
Yogurt	65
Yeast	25
Critic acid	20

Ahanowitz and Cohen (1981) tabulated microbially produced substances (which generally fell into three categories), and their sales in the United States by more than 10 American Companies in 1979. The substances included anti-infective agents (including antibiotics), enzymes and vitamins. Among the antibiotics, broad spectrum and the penicillin alone were valued at six hundred and two hundred billion dollars respectively.

Digestive enzymes had market value of sixteen billion dollars, while vitamin sales alone amounted to up to 133 billion dollars.

In view of the foregoing economic benefits, the developed countries and various international agencies have consistently encouraged developing countries to explore their microbiological resources with a view to harnessing their potentials for economic development. In addition, microbiological resources centres (MIRCENS) have been set up for developing countries for conserving potentially useful microbes. Details of various strategies or establishments that have been proposed or developed for management and conservation of microbial resources of developing countries are available (Anon, 1979). Unfortunately, many developing countries including Nigeria, seem to be relatively naïve in developing their microbial resources.

DIVERSITY OF NIGERIA'S MICROBIAL RESOURCES AND CONSTRAINTS TO THEIR CONSERVATION AND UTILIZATION

To date, there is hardly any significant evidence that Nigerian society at large, or various levels of government, or the private sector, are aware of the economic potentials of microbes, and of the need to harness them through strategies clearly articulated and proposed by various Organizations and Agencies. This is without prejudice to the depth of awareness that have developed on these issues in academic institutions and academic societies in the country. In this regard, it should be pointed out that the academia had been aware that various indigenous food and beverage fermentations are mediated by microbes just like those of the western world. Indeed, since 1959 microbiological studies on Nigerian fermented foods and beverages have occupied the attention of scientists and relevant literature reviews are available (Odunfa, 1975; Okagbue, 1988a). What appears to be the first study was carried out on gari fermentation, by Collard and Levi (1959). The study was important because it showed, among other things, that the process by which cassava (a naturally toxic product) is detoxified for human consumption, had a microbiological basis. Other studies have shed some light on the great diversity of Nigerian fermented products, and of the starting raw materials from which they are produced. What seems to be more relevant here is that the microorganisms

that are known to be associated with food and beverage fermentations are as diverse as both the final products and the starting materials. The diversity of the final products with their associated aroma and tastes and other organoleptic attributes, reflect those of metabolic end products of relevant microorganisms. There can be no doubt that the microbes involved in our well known cultural food fermentations which have continued to be mainly village-level activities, are as heterogeneous as economic plants and animals whose contributions to our national economy are not in doubt. Surely, the microorganisms involved in our food and average fermentations can be harnessed for their obvious economic importance and that may lead to development of cottage industries in the country.

It seems pertinent to point out that the field of food fermentation is not the only area where Nigeria's indigenous / microbial biodiversity has been explored for its economic potentials. Indeed, in one of the reviews cited earlier (Okagbue, 1988a) considerable insight was provided on forays, by Nigerian microbiologists, into microbial production of antibiotics, bioinsecticides, biogas, to mention only a few.

Apparently, the British pioneered efforts to explore the potential of Nigeria's indigenous microflora to produce antibiotics. According to published information (Bhatte, 1955) some British experts isolated a strain of *Bacillus pumilus* with broad spectrum antibiotic activity, when they screened a sample of soil collected from Northern Nigeria. Since that pre-independence study, at least one local isolate of *Streptomyces* sp, and one *Bacillus alvei*, have also been shown to produce antibiotics effective against pathogenic microorganisms (Okagbue, 1988a). In connection with bioinsecticides, pioneering work done by Okafor (1965) described one *Arthrobacter* sp, that had insecticidal activities against the larvae of *Anopheles* sp. It is likely that other local insecticidal microbial strains may have been explored in attempts to find solutions to problems caused by mosquitoes, tse-tse-flies, houseflies and other insects. Also, studies on microbial production of enzymes such as amylases, proteases, linamarase, and others that can be used in processing various carbohydrate-based foods beverages, have been described by many Nigerian scientists, see for example, the review by Okagbue (1988a). Other microbial strains potentially useful for producing biomass such as brewery, bakery and winery yeast, or as a source of single cell protein, have been published (Okagbue 1988a, 1988b). In relatively recent times, production of biosurfactants, and degradation of crude oil by local strains of microorganisms, have been described by various scientists; cultures from these studies are potentially useful for environmental bioremediation. Unfortunately, one major hindrance to detailed studies and commercial exploitation of these and other micro organisms that constitute invisible components of Nigeria's diverse natural resources, is that the organisms are rarely, if at all, preserved in the country.

As mentioned earlier in this paper, conservation of microbes that have potentials for industrial or other applications is considered to be equivalent to conservation of plants and animals. Also microbial Culture Collection-repositories of microorganisms- were extolled for their

relevance to research and exploitation of microorganisms, and the importance attached to them by all the developed Western countries as well as the concept of MIRCENS were also described earlier. The unfortunate state of microbial culture conservation in developing countries, as well as the expected contributions of Culture Collections to future development of those countries will be appreciated from this statement (Anon, 1979).

… "In developing countries, cultures, and the microbiologists who maintain and use them, may represent important resources that are not fully appreciated or utilized for national development objectives. Brought together, they could at a minimum serve as an expert source of advice and insight for development authorities into alternative ways in which microorganisms can be exploited for development objectives…in the context of local resources and constraints".

The above statement aptly fits the Nigerian situation. The country's microbiologists desire that microbiology be accorded due recognition as natural resources and that a national Culture Collection be established and equipped for conservation of desirable microbes. Although in 1983, the Federal Government, through the then Ministry of Science and Technology, co-sponsored an international workshop on microbial type Culture Collection, under the auspices of the Nigerian Society for Microbiology, to date, no national Culture has been established. Consequently, many promising microbial isolates from the country are either discarded, or sent abroad for preservation, by Nigerian scientists; information on the isolates frequently occurs in catalogues of foreign Culture Collections. The country's invisible natural (microbial) resources and drained, and Nigerian microbiologists are often required to spend scarce foreign currency to reacquire relevant cultures when they are needed for research purposes. Sometimes, cultures lose viability when efforts are made to preserve them locally, due to Nigeria's erratic power supply and to other local factors detrimental to long-term viability of microorganisms.

Implicit from the above paragraph is that it is advantageous to preserve indigenous microbial isolates locally under suitable conditions. This becomes very critical because some organisms may be relatively rare in occurrence. A typical example is Corynebacterium manihot, a species which was initially isolated from gari fermentation (Collard and Levi, 1959), and sent to National Collection of Industrial Bacteria (NCIB) at Aberdeen, Scotland. Since that first isolation, subsequent studies on gari fermentation in various laboratories in Nigeria, have never yielded new strains of that bacterium.

Even if microbes are recognized as natural resources and their collections are kept, a country must have commercial enterprises committed to investing in processes that require the use of relevant microbes. In this regard, Nigeria again has obvious shortcomings, as relevant enterprises are difficult to find. In developed countries, brewing, bakery and dairy industries and organizations have been instrumental in upgrading the traditional fermentations associated with manufacture of beers, bakery and dairy products. Nigerian elites and the wealthy class seemingly prefer the western highly refined products like the lager beers and wines,

flavor enhancers like monosodium glutamate, to their local counterparts whose upgrading, in consequence, is likely to continue to be neglected. It seems appropriate to recall that the same foreigners who introduced their products to our markets championed and encouraged research into our local products that have widespread acceptance and cultural significance. For obvious reasons, commercialization of our local products will depend more on indigenous businesses than on foreign enterprises. It should be noted that even as Nigeria lags behind in developing indigenous microbial processes, some progress has been made elsewhere in Africa. For example, in southern Africa, the production of local beer (called bantu or kaffir beer) has become a gigantic industry (Steinkraus, 1987), and MIRCENS has also been established in that region (Prior and Kock, 1996).

Overall, it can be stated that the foundations for appreciating microbes as natural resources that can be harnessed for national development objectives in nigeria, are anything but strong. As long as traditional fermentations remain underdeveloped and neglected, and Culture Collections are not established and equipped, the prospect of applying microorganisms to higher levels of national development efforts such as clearing oil spills and mining low grades ores, will continue to be remote.

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