pyrite (an iron sulphide mineral) and arsenopyrite (an arsenic containing iron sulphide mineral). According to Brierley [32], to effectively recover the precious metals, the sulfides must be degraded (oxidized) to expose the precious metals. Once the sulphides are sufficiently degraded to expose the gold and silver, a dilute solution of cyanide is used to dissolve the precious metals. If the occluded gold and silver [32] are not exposed by breaking down the sulphide minerals, the cyanide cannot help in the release of the metals and recovery will be low. The ferric iron that is produced by the microorganism is the chemical agent that breaks down (oxidizes) the sulfide mineral. The microorganisms can be thought of as the manufacturing facility for producing the ferric iron. Microorganisms in the ore are destroyed by lime. Cyanide leaching can be accomplished in another heap or the oxidized and lime-conditioned ore can be ground and cyanide leached in a mill. The residue slurry is rinsed with fresh water, neutralized with lime, subjected to solid/liquid separation, and the solid residue is cyanide leaching to extract the gold. Gold recoveries are in the 95–98% range.

Advantages of biomining [32] using organisms include the following.

(1) Biomining microorganisms do not need to be genetically modified; they are used in their naturally occurring form.

(2) Unlike humans, animals, and plants, microorganisms reproduce by doubling; that is, when there is abundant food (iron and sulfur) for biomining microbes and optimal conditions (sufficient oxygen, carbon dioxide and a sulfuric acid environment), a microbe will simply divide. Thus, in heap of minerals biooxidation for pretreating gold ores, there are about one million microbes per gram of ore.

(3) High altitudes have no effect on the biomining microorganisms. However, additional air must be supplied to give the organisms an optimal performance.

(4) Biomining using microorganisms does not produce dangerous waste products. Base metals, for example, zinc and copper are recycled and neutralized with lime/limestone.

(5) The biomining microbes cannot escape from the heap or bioreactor to cause environmental problems. These microbes exist in the environment only where conditions are suitable (i.e., sources of iron and sulfur are oxidized, air and a sulfuric acid environment).

Biomining as a biotool has not been explored in Nigeria. Though Nigeria has many solid minerals in different states of the country, some of the minerals are tin (found in Plateau, Nassarawa, Kaduna, Bauchi and Gombe states), gold (found in Oyo, Osun and Ondo states), copper (Edo and Benue states), tantalite (Gombe, Plateau, Kaduna, and Nasarawa states), and uranium (Bauchi state) among others. The procedures, equipments, nonawareness/interest by government as well as competition with the physicochemical methods of extraction of these minerals are the greatest limitation in the exploitation and usage of this biotool in mining of minerals from their ores. Providing information to Nigeria scientists, ministries and government agencies is the solution to this limitation. Thus, the essence of the suggestion here is to create awareness in this regard.

10.3. Biomonitoring. In a broad sense, biological monitoring involve any component that makes use of living organisms, whole or part as well as biological systems to detect any harmful, toxic, or deleterious change in the environment. There are various components employed in biomonitoring of contaminants in the environment. They include biomarkers (biological markers), biosensors, and many others.

Biomonitoring or biological monitoring is a promising, reliable means of quantifying the negative effect of an environmental contaminant.

Biological Markers. A biomarker is an organism or part of it, which is used in soliciting the possible harmful effect of a pollutant on the environment or the biota [37]. Biological markers (biomarkers) are measurement in any biological specimen that will elucidate the relationship between exposure and effect such that adverse effects could be prevented [38]. The use of chlorophyll production in *Zea mays* to estimate deleterious effect of crude oil contaminants on soils is a typical plant biomarker of crude oil pollution [11]. When a contaminant interacts with an organism, substances like enzymes are generated as a response. Thus, measuring such substances in fluids and tissue can provide an indication or "marker" of contaminant exposure and biological effects resulting from the exposure. The term biomarker includes any such measurement that indicates an interaction between an environmental hazard and biological system [39]. It should be instituted whenever a waste discharge has a possible significant harm on the receiving ecosystem. It is preferred to chemical monitoring because the latter does not take into account factors of biological significance such as combined effects of the contaminants on DNA, protein, or membrane. Onwurah et al. [37] stated that some of the advantages of biomonitoring include the provision of natural integrating functions in dynamic media such as water and air, possible bioaccumulation of pollutant from 10^3 to 10^6 over the ambient value, and/or providing early warning signal to the human population over an impending danger due to a toxic substance. Microorganisms can be used as an indicator organism for toxicity assay or in risk assessment. Tests performed with bacteria are considered to be most reproducible, sensitive, simple, economic, and rapid [40] (Table 3).

10.4. Biosensor. A biosensor is an analytical device consisting of a biocatalyst (enzyme, cell, or tissue) and a transducer, which can convert a biological or biochemical signal or response into a quantifiable electrical signal [46]. A biosensor could be divided into two component analytical devices comprising of a biological recognition element that outputs a measurable signal to an interfaced transducer [24]. Biorecognition typically relies on enzymes, whole cells,