Vol. 14(1), pp. 26-31, January-June, 2022
DOI: 10.5897/JECE2021.0486
Article Number: 15E417B69246
ISSN: 2141-226X

http://www.academicjournals.org/JECE

ACADEMIC JOURNALS
expand your knowledge

Journal of Environmental Chemistry and Ecotoxicology

Full Length Research Paper

Evaluation of heavy metals on soil microflora diversity in Robertkiri, Idama and Jokka in Niger Delta Area of Nigeria

Duke Okoro[1*] and Ikyaahemba Philip Tordue[2]

[1]Department of Chemistry, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria.
[2]Soils and Land Management Division, Nigerian Institute for Oil Palm Research, Benin City, Edo State, Nigeria.

Received 17 December, 2021; Accepted 3 March, 2022

The increase in the population and industrial growth has led to increased production of industrial and domestic waste, which contains heavy metals in different forms, hence affect the diversity and activities of soil microflora and environmental sustainability. This research was aimed at evaluating the heavy metals on soil microflora diversity in soils of Robertkiri, Idama and Jokka in Akuku-Toru Local Government Area in River State Nigeria. Soil samples were collected randomly from each location at 0-15 and 15-30 cm depth, respectively. The heavy metal contents of soil were determined using standard methods, while the microbial analysis of samples was determined by the enumeration of total heterotrophic bacteria (THB) and fungi and hydrocarbon utilizing bacteria and fungi on plate count Agar at 37°C, and the count recorded after 4 h using standard methods. Results showed that Fe concentration was highest in the contaminated locations at 15-30 cm depth with values 1362.01, 894.01 and 674.11 mg/kg for Robertkiri, Idama and Jokka compared to 0-15 cm depth and the control. Similar trend was observed at 15-30 cm depth for Zn 33.61, 41.20 and 33.98 mg/kg within the study locations. Whereas Cu and Cr had lowest concentration of 0.49 and 0.78 mg/kg in Robertkiri, 0.74 and 1.17 mg/kg in Idama and 0.76 and 1.87 mg/kg in Jokka at 15-30 cm depth. The THB and total heterotrophic fungi (THF) count was relatively low and ranged between 0.59 and 2.85 cfu at 0-15 and 15-30 cm depth in Robertkiri and Idam. While at jokka, THB and THF count ranged between 0.23 and 1.94 cfu at 0-15 and 15-30 cm depth compared to control. Likewise, the hydrocarbon utilizing bacteria (HUB) and hydrocarbon utilizing fungi (HUF) count was found to be low across depth in all the three locations in relative to the control. The study revealed that there is a gradual accumulation of heavy metals and the concentration was high in the contaminated soils than the control. The low count of soil microflora in the study locations may be due to the high levels of heavy metals observed in the contaminated soils from different locations.

Key words: Heavy metals, microflora diversity, Niger delta, evaluation, polluted soils.

INTRODUCTION

Heavy metals are an assemblage of high-density metals and are toxic when the threshold exceed. These metals

*Corresponding author. E-mail: okoro.duke@fupre.edu.ng.

are dispersed into the environment either by natural or human activities such as industrial or municipal waste, (Olajire et al., 2003), automobile and domestic waste discharge (Nkwunonwo et al., 2020). Changes in soil properties caused by human activities resulted in the degradation of soil which leads to reduction in animal, plant and microbial communities, and their effects on soil productivity have generated significant research concern for many years (Zhou et al., 2014). The occurrence of heavy metals in the soil ecosystem posed a serious challenge globally due to the adverse effect it has on the environment via absorption by plants, alteration of soil reactions which reduces the soil quality for sustainable agricultural production (Masindi and Muedi, 2018). The heavy metals contamination is a threat to soil quality worldwide, and therefore, change the diversity and population of soil microbes (Xie et al., 2017). In addition, losses and stress imposed by chemical contamination through the use of herbicides and pesticides, as well as chemical imbalances through soil acidification or salinization may result in impaired soil biological functioning (Lavelle and Spain, 2001). Conversely greater attention in agricultural systems to managing the soil biological processes, through providing a beneficial environment for soil macrofauna can restore soil health and improve soil fertility (Nuria and Lavelle, 2008). The responses of microbial communities to heavy metal contamination have been investigated (Ranjard et al., 2000; Sandaa et al., 2001; Renella et al., 2005). The occurrence of heavy metals has been found to reduce the amount of soil microbial biomass (Chander et al., 1995), leading to a decrease in functional diversity (Kandeler et al., 1996). Audu and Idowu (2015) and Haruna et al. (2019) also carried out a study on the level of heavy metals in water used for irrigation and the result showed a high level of heavy metals in the soils of the area. Many studies have engrossed on the effects of heavy metals on root exudations, soil microbial, and soil enzyme activity and so on. In spite of the large scale of crude oil activities in Niger Delta Nigeria little or no attempt has been made to determine the effect of heavy metals on soil microfauna diversity in the study area. It is very pertinent to conduct an empirical investigation for the study area for appropriate decision making with respect to environmental quality and sustainable soil management. Thus this present study investigates the effects of heavy metals on soil microflora diversity in Robertkiri, Idama and Jokka in Niger Delta area of Nigeria.

MATERIALS AND METHODS

Description of the study area

Robertkiri, Idama and Jokka are located in Akuku-Toru Local Government Area in River State, Nigeria. Akuku- Toru is an oil-producing area in river state and occupies a landmass of 1,443 km^2 and a population of 156, 600 (UNDP, 2016). The major occupation of the inhabitants includes farming, milling of palm oil, making of local gin, fishing and trading. The map of the study area is presented in Figure 1.

Geology of the study area

The Niger delta basin is an intrinsic part of the sedimentary basins of southern Nigeria. The dominant sedimentology characteristics of the soils in this region is influenced by depositional sedimentary pile divided into three diachronous lithostratigraphic formation, the Akata, Agbada and Benin formation from Eocene to Recent (Raijers, 2011).

Soil sample collection and analysis

The surface and sub-surface soil samples were collected randomly from each location at 0 -15 cm and 15 - 30 cm depth at each sampling point. Samples were air-dried at ambient temperature, ground and sieved with a 2 mm sieve and characterized for soil physical, chemical and microbiological characteristics of microflora present in the soil sample. Particle size was determined by Bouyoucos hydrometer (Gee and Or, 2002). Available Phosphorous (P) was determined by Bray P-1 method (Anderson and Ingram, 1993). Total Nitrogen (N) was determined by macro-kjedhal method (Brookes et al., 1985). Soil pH was determined in a 1:2 soil to water suspension using a pH meter (Thomas, 1996). Exchangeable bases were extracted using NH_4OAC buffered at pH 7.0 (Thomas, 1982). While Potassium (K) and Sodium (Na) were read from a flame photometer, Exchangeable Calcium (Ca) and Magnesium (Mg) were determined using atomic absorption spectrophotometer with cathode lamp at different wavelength of absorption.

Determination of heavy metals in soil samples

The soil was digested through the wet digestion methods as described by Anderson (1974). 10 g of soil was weighed into a clean 300 ml calibrated This was then filtered through Whatman No. 42 filter papers digestion tube and 5 ml of concentrated sulphuric acid (H_2SO_4) was added in the fume hood, swirled gently. 5 ml of HCl was added and then heated to 240°C for one hour and stored in pre-cleaned polyethylene bottles for further analysis. Atomic Absorption Spectrophotometer (AAS) was set for: Iron, Zinc, Copper, Chromium. Cadmium, Nickel and Lead. Thereafter, the heavy metal contents of soil were determined using standard methods (APHA, 1995; Ademoroti, 1996).

Microbiological analysis

The microbial analysis of samples was determined by the numeration of total heterotrophic bacteria (THB) and fungi and hydrocarbon utilizing bacteria and fungi on plate count Agar at 37° C and the count recorded after 4 h using standard methods (ISO 4833-1, 2013). Indirect cell count was carried out to determine the total viable microbial populations. The test methods used was the ASTM D5465 – 93 to determining Microbial Colony Counts from soil Analysis by Plating Methods, and APHA 907: Standard PlateCount. Total microbial colonies were calculated as follows:

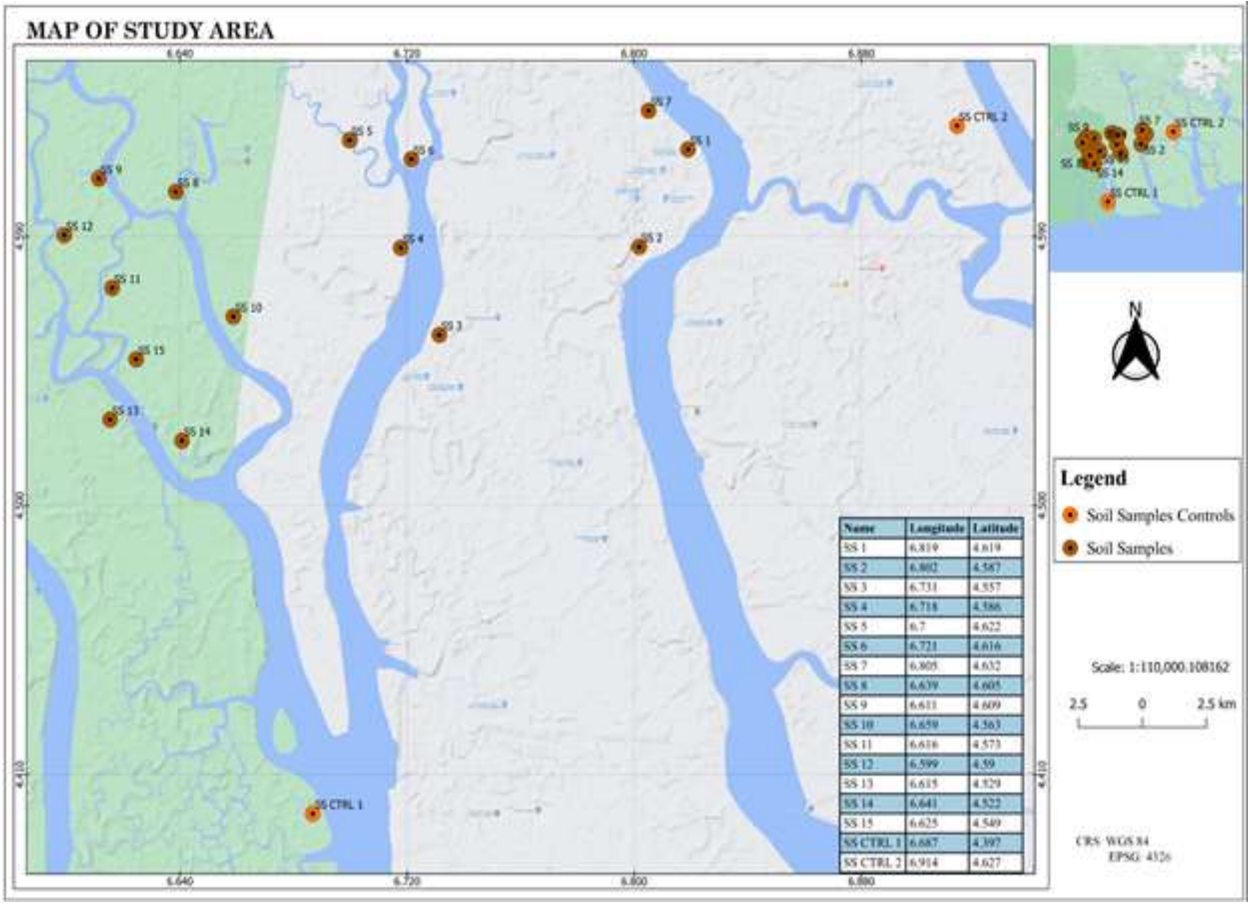

Figure 1. Map of study area.

Plate Count (cfu/ml) = No. of Colonies on Plate × Dilution factor

Statistical analysis

Statistical analysis was carried out for the basic descriptive statistics to determine the significance of difference between the controls and sampling point at a probability level of 5% using the Data Analysis package of Microsoft Excel 2016.

RESULTS AND DISCUSSION

The selected soil physical and chemical properties in the study area are presented in Table 1. The sand content ranged from 74.8 to 86.3% and 80.6 to 86.3% for surface and subsurface soils in all the locations. The clay content of the soils ranged between 8.0 to 13.2% and show a decreasing trend with depth across the locations relative to the control. The observed decrease in the clay content conformed with the work of Raji et al. (2001) in Northern Nigeria, who reported that clay content also decreased with depth. No trend was observed on the silt content at 0-15 and 15 – 30 cm depth in Robertiki, Idama and Jokka (Table 1). The pH values in the three locations ranged between 4.7 and 6.2. This result is contrary to the results of Kentucky (2001) who reported that large variety of aquatic species is found within the pH range of 6.5 to 8.0. The textural classes of the soils ranged between loamy sand to clay loam at depth. Total N content ranged between 0.029 to 0.092 mg/kg and 0.113 to 0.316 mg/kg across depth. However, N content was high in the control than other locations. Similar trend was observed on P content in the three locations relative to the control. No trend was observed in K content in all the locations evaluated. Na^{2+}, Ca^{2+} and Mg^{2+} content of the soils decreased with depth across the locations. The concentration of heavy metals in the soil is presented in Table 2. There is a spatial variability in the concentration of individual heavy metals among the locations. The result showed that Fe concentration was highest in the contaminated locations at 15-30 cm depth with values 1362.01, 894.01 and 674.11 mg/kg for Robertkiri, Idama and Jokka compared to 0-15 cm depth and the control.

Table 1. Soil physical and chemical properties of soils of Robertiki, Idama and Jokka.

Soil characteristics	Soil depth (cm)							
	Control		Robertiki		Idama		Jokka	
	0 - 15	15 - 30	0 - 15	15 - 30	0 - 15	15 - 30	0 - 15	15 - 30
Sand (%)	83.0	80.6	79.6	86.3	76.8	83.3	74.8	80.4
Clay (%)	8.6	10.3	8.0	13.2	7.3	10.1	10.2	9.8
Silt (%)	6.8	10.8	4.4	9.7	5.6	15.9	13.7	9.5
Textural class	LS	LS	LS	LS	LS	LS	LS	LS
pH	5.7	5.3	5.0	6.2	4.7	5.9	5.2	4.8
Total N (mg/kg)	0.092	0.316	0.078	0.113	0.018	0.127	0.029	0.131
Available (p) cmol/kg	3.6	4.1	3.7	4.8	3.1	5.2	3.2	5.6
K^+ (mg/kg)	2.41	2.18	1.35	3.48	1.47	2.87	1.64	1.28
Na^{2+} (mg/kg)	3.63	3.78	2.81	4.10	2.33	4.87	4.14	3.61
Ca^{2+} (mg/kg)	1.40	1.69	1.99	2.15	1.50	1.83	1.70	3.15
Mg^{2+} (mg/kg)	2.91	2.41	2.69	3.37	2.15	2.67	1.92	2.00

Similar trend was observed at 15-30 cm depth for Zn 33.61, 41.20 and 33.98 mg/kg within the study locations. Whereas Cu and Cr had lowest concentration of 0.49 and 0.78 mg/kg in Robertkiri, 0.74 and 1.17 mg/kg in Idama and 0.76 and 1.87 mg/kg in Jokka at 15-30 cm depth (Table 2) The THB and total heterotrophic fungi (THF) count was relatively low and ranged between 0.59 to 2.85 cfu at 0-15 and 15-30 cm depth in Robertkiri and Idam. While at jokka, THB and THF count ranged between 0.23 to 1.94 cfu at 0-15 and 15-30 cm depth compared to control (Table 3). The variability of the heavy metals in the study area may be due to the anthropogenic activities and geological composition of the soil (Ebong et al., 2020). The high concentration of heavy metals found in the contaminated locations than the control may be adduced to the industrial waste/gas flaring released from oil exploration activities of oil companies which contribute to the increase of the heavy metal load in the soil. This observation is in line with Kausar et al. (2019), who reported that the major causes of heavy metals in the soil could be attributed to discharge of industrial and domestic waste, sewage sludge and effluent. The concentration of heavy metals in the soil of the study area is in the order of Fe > Zn > Cr > Cu > Cd > Pb. The microbiological characteristics of soils in the study location are presented in Table 3. The THB and THF count was relatively low and ranged between 0.59 to 2.85 cfu/mg × 10^3 at 0-15 and 15-30 cm depth in Robertkiri and Idam. While at jokka, THB and THF count ranged between 0.23 to 1.94 cfu × 10^3 at 0-15 and 15-30 cm depth compared to control. Likewise, the hydrocarbon utilizing bacteria (HUB) and hydrocarbon utilizing fungi (HUF) count was found to be low and ranged between 0.19 and 0.71 cfu/mg × 10^3 and 0.06 to 0.19 cfu/mg × 10^2 and increased across depth in all the three locations relative to the control (Table 3). The low count of soil microflora in the study locations may be due to the high levels of heavy metals in the contaminated locations. This observation is consistent with earlier findings by Dian (2018), who reported that increase in heavy metals in soil and environment would interfere with key biological processes and reduction in microbial diversity**.**

Conclusion

The study revealed that there is a gradual accumulation of heavy metals and the concentration was high in the contaminated than the controlled locations. The low count of soil

Table 2. Characteristics of heavy metals in soils of Robertiki/Idama/Jokka.

Heavy metals	Units	Control		Robertkiri		Idama		Jokka	
Soil depth	**cm**	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**
Fe	mg/kg	741.36	1217.3	844.23	1362.01	623.45	894.01	386.91	674.11
Zn	mg/kg	11.63	28.41	23.47	33.61	19.57	41.20	21.65	33.98
Cr	mg/kg	7.46	1.84	4.33	0.78	3.98	1.17	11.27	1.87
Pb	mg/kg	0.074	0.036	0.059	0.017	0.136	0.096	0.119	0.050
Cu	mg/kg	3.19	0.90	4.75	0.49	3.25	0.74	5.02	0.76
Cd	mg/kg	0.132	0.212	0.632	1.003	0.741	0.933	0.128	0.134
Hg	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
V	mg/kg	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Ni	mg/kg	7.96	2.35	10.52	3.24	7.41	1.96	5.84	2.04
Ba	mg/kg	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Ar	mg/kg	<0.003	<0 .003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
As	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 3. Microbiological characteristics of soil at Robertiki/Idama/Jokka area.

Soil microorganisms	Control		Robertiki		Idama		Jokka	
	Soil depth (cm)							
	0 - 15	**15 - 30**	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**	**0 - 15**	**15 - 30**
Total heterotrophic bacteria (THB)Cfu/mg × 10^3	3.68	3.08	2.84	2.15	2.35	2.85	0.89	1.94
Total heterotrophic fungi (THF)Cfu/mg ×10^3	0.98	0.86	0.59	0.87	0.77	0.93	0.23	0.38
Hydrocarbon utilizing bacteria (HUB)Cfu/mg x 10^3	0.51	0.63	0.37	0.71	0.51	0.69	0.19	0.45
Hydrocarbon utilizing fungi (HUF)Cfu/mg ×10^2	0.15	0.18	0.07	0.23	0.07	0.17	0.06	0.19

microflora in the study locations may be due to the high levels of heavy metals in the contaminated locations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGMENT

The authors appreciate the benevolence of Dukoria International Limited for their logistics support and laboratory analysis.

REFERENCES

Ademoroti CMA (1996). Standard Method for Water and Effluents. Analysis Foludex Pre Ltd. Ibadan.

American Public Health Association (APHA) (1995). “Standard Methods for the Examination of Water and Wastewater”. 19th Edition. Washington D.C.

Audu A, Idowu A (2015). The effect of Chaallawa Industrial Estate on the physicochemical properties and heavy metals levels of portable water supply in kano Metropolis, Nigeria.

Journal of Geoscience and Environmental Protection 5:17-22. https://doi:10.4236/gep.2o15.32003 DOI: 10.1080/15693430802650449.
Brookes PC, Landman A, Prudes G, Jenkenson DS (1985). Choloroform Fumigation and release of soil Nitrogen; A rapid extraction Methodology to measure Microbial Biomass and Nitrogen in soil. Soil Biology and Biochemistry 17(6):837-842.
Chander K, Brookes PC, Harding SA (1995). Microbial biomass dynamics following addition of metal-enriched sewage sludges to a sandy loam. Soil Biology & Biochemistry 27(11):1409-1421.
Dian C (2018). Effect of heavy metals on soil microbial community. IOP Conference Series, Earth Environmental Science 113:1-5.
Ebong GA, Ettesan ES, Dan EU (2020). Impact of Abbatoir wastes on trace metal accumulation, speciation and human health-related problems in soils within Southern Nigeria. Air, Soil and Water Research 13:1-14.
Gee GW, Or D (2002). Particle size Analysis. In: Dane, J.H G.C. Topp (eds) Methods of Soil Analysis. Soil Science Society of America, Madison WI 4(5):255-293.
Haruna YI, Koki FS, Nura AM and Ibrahim MU (2019). Determination of Spatial Distributions of heavy metals about River Jakara, Kano Nigeria. Bayero Journal of Physics and Mathematical Sciences 10(1):76-84.
ISO 4833-1 (2013). Microbiology of the Food Chain- Horizontal Method for the Enumeration of Microorganisms. International Organization for Standardization. https//www.boutique.afnor.org/resources/28167a60-b20a-47a9-b620-ec8823348a5e.pdf.
Kausar FA, Ahmad SR, Baqar M (2019). Evaluation of surface water quality on spatio-temporal gradient using multivariate statistical techniques: a case study of River Chenab, Parkistan. Polish Journal of Environmental Studies 28(4):2645-2657.
Kandeler F, Kampichler C, Horak O (1996). Influence of heavy metals on the functional diversity of soil microbial communities. Biology and Fertility of Soils 23(3):299-306.
Kentucky Water Watch (2001). Dissolved Oxygen and Water Quality: http:/fluid. Stateky Us/www/ramp/rms2.htm.
Lavelle P, Spain A (2001). Soil Ecology, Kluwer Academics. The Netherlands.
Masindi V, Muedi KL (2018). Environmental contamination by heavy metals. Intechopen pp. 115-133. http://dx.doi.org/10.5772/intechopen.76082.
Nkwunonwo UC, Odika PO, Onyi NI (2020). A review of health implications of heavy metals in food chain in Nigeria. The Scientific World Journal pp. 1-11.
Nuria R, Lavelle P (2008). Soil Micro fauna, Field Manual. Food and Agricultural Organization of the United Nation pp. 14-18.
Olajire AA, Ayodele ET, Oyediran GO, Oluyemi EA (2003). Levels and speciation of heavy metals in soils of industrial southern Nigeria, Environmental Monitoring and Assessment 85(2):135-155.
Raijers TJA (2011). Stratigraphy and sedimentology of Niger delta. Geologos 17 (3):133-162.
Raji BA, Malgwi WA, Falaki AM, Kparmwang T (2001). Characterization and classification of soils of the jangargari Aluvial complex in the semi- Arid region of Nigeria.
Renella G, Mench M, Landi L, Nannipieri P (2005). Microbial activity and hydrolase synthesis in long-term Cd-contaminated soils. Soil Biology and Biochemistry 37(1):133-139.
Sandaa RA, Torsvik V, Enger Ø (2001). Influence of long-term heavy-metal contamination on microbial communities in soil. Soil Biology and Biochemistry 33(3):287-295.
Thomas GW (1982). Exchangeable cation, Methods of soil Analysis. Part 2. Agronomy Monograph, a second edition, ASA and SSSA Madisson pp. 159-165.
Thomas GW (1996). Soil pH. Soil acidity. In: Methods of soil analysis Part 3. Chemical Methods, Soil Science Society of America 5:159-165.
United Nations Development Programme (UNDP) (2016). Niger Delta Human Development Report.
Xie FY, Jiu-ming Z, Li T, Jian-hua G (2017). The effect of heavy metal contamination on the bacteria community structure at Jiaozhou Bay, China, Brazilian Journal of Microbiology 48:71-78.
Zhou W, Lv TF, Chen Y, Westby AP, Ren WJ (2014). Soil physicochemical and biological properties of paddy-upland rotation: a review. Scientific World Journal 4:1-8.