

1 **DISTRIBUTION OF ECOSYSTEM HEALTH INDICATORS FOR**
2 **BIOMONITORING OF OIL POLLUTION IN THE WESTERN NIGER DELTA,**
3 **NIGERIA**

4
5 **ABSTRACT**

6 As a result of the limitations of physical and chemical methods for monitoring pollution,
7 interest on the more reliable biological monitoring intensified over the past four decades.
8 Soil microarthropods, specifically the free-living mites (Cryptostigmata, Mesostigmata,
9 Prostigmata) and Collembolans were used as monitor (ability to withstand pollutants) and
10 indicator (sensitive to pollutants) species in the Eastern Niger Delta. Study was undertaken
11 in the Western Niger Delta (Delta State) across three eco-vegetational zone (freshwater
12 swamp forest, Mangrove swamp forest, Lowland rainforest) in the area to determine if these
13 ecosystem health indicators were widely distributed in these zones. Collections were made
14 during the rainy season over a 4-month period. A modified Berlese-Tullgren funnel was
15 used for extraction of microarthropods. Free-living mites: Cryptostigmata (Oribatida) –
16 *Archogozettes magnus*, *Opiida sp.*, *Annecticarus sp.*, *Bicyrthermania negeriana*, *Cephalida*
17 *sp.*, *Scheloribates sp.*, *Galumnida sp.*, Mesostigmata (Gamasida) - *Asca sp.*, *Trichuropodida*
18 and Collembolan – *Paronella sp.*, were widely distributed across the eco-vegetational
19 zones. These mesofauna contained the full complement of monitor and indicator species. It
20 is therefore possible to use these mesofauna for biomonitoring of oil pollution across the
21 Niger Delta (eastern and western sectors), Nigeria.

22 Key Words: Pollutants, Ecosystem Health Indicators, Mites, Collembolans, Biomonitoring,
23 Niger Delta, Nigeria.

24 **INTRODUCTION**

25 The effective dose of a pollutant in an individual, determined by physical or chemical
26 methods may be much lower than the result obtained. The total concentration may be raised
27 by high levels of surface contamination or the binding of pollutant to inert sites. Thus the
28 biological significance of the concentration in the individual may be overestimated. In
29 contrast, biological monitoring assesses the significance of a pollutant for an organism in its
30 habitat and other individuals in the community. Monitor and indicator species are used to
31 measure pollutant impact (Martin and Coughtry, 1982). Monitor species have the ability to

32 withstand pollutants and they are used to assess the scale and distribution of the pollutant.
33 In contrast, indicator species are sensitive to the pollutant and their presence or absence
34 indicates a significant level of contamination.

35 Mites and other microarthropods (Including Collembolans), part of the mesofauna play a
36 crucial role in the context of soil biodiversity, decomposition and mineralization processes
37 (Seastedt, 1987; Tiann *et al.*, 1998). Among the microarthropods, the feeders (mycophages)
38 are dominant Collembolans free-living astigmatid mites and most oribatids
39 (Cryptostigmmites) have well-developed mouthparts, capable of fragmenting organic matter,
40 while feeding on the microflora adhering to detritus. Fragmentation and communitation are
41 important to the decomposition and mineralization processes by creating new surface area
42 for microbial colonization (Fountain and Hopkin, 2005). The decomposer community
43 received greater interest within soil ecology in the past six decades (Bardgett, 2002). The
44 free-living mites (Cryptostigmata, Mesostigmata, Prostigmata) and Collembolans have been
45 used as monitor and indicator species to determine ecosystem health in Rivers State,
46 Eastern Niger-Delta (Gbarakoro *et al.*, 2010; Okiwelu *et al.*, 2011a & b; Gbarakoro *et al.*,
47 2011).

48 This study was undertaken to produce baseline data on the species composition of mites and
49 Collembolans in relatively undisturbed habitats in mangrove swamp forest, freshwater
50 swamp forest, lowland rainforest in Delta State, Western Niger Delta, Nigeria. If they are
51 distributed across these zones, they can be used for biomonitoring of oil pollution across the
52 Niger Delta.

53 MATERIALS AND METHODS

54 The mangrove swamp forest is located on the bank of the Isaba River, Warri North Local
55 Government Area (LGA) and the freshwater swamp forest, at Merogun, Warri South LGA,
56 Delta State. Collections were made from two sites in each of in each of the LGAs. At Isaba
57 in Warri North LGA, collections were made from the mangrove forest and in lowland
58 rainforest approximately 200m away. In Warri South LGA, at Merogun, collections were
59 from the freshwater swamp forest and approximately 200km away, in farm bush located in
60 lowland rainforest.

61 Studies were conducted over a 4-month period, June-September, during the rainy season. At
62 each location, an area 30.00cmx30.00cm was delineated. Each delineated area was divided
63 into 4 sub-plots and collections made monthly in rotation from each sub-plot. Collections

64 were made at 08.00-09.00hrs from litter and depths of 0.50cm, 5.0-10.0cm, 10.0-15.0cm;
65 15.0-20.0 cm, 20-25cm and 25-30cm. Samples were placed in labeled transparent bags. A
66 modified Berlese-Tullgren funnel was used to extract the microarthropod species were
67 identified to family levels by keys and illustrations provided by Badejo (1994) and type
68 specimens in the Entomology and Pest Management Laboratory, University of Port
69 Harcourt.

70 RESULTS

71 In the mangrove swamp forest, six species of Cryptostigmata (Oribatida) were collected:
72 *Archogozettes magnus*, *Annecticarus sp.*, *Bicyrthermania negeriana*, *Cephalida sp.*,
73 *Scheloribates sp.*, *Galumnida sp.*; a species of Mesostigmata (*Gamasida*) *Asca sp.* and a
74 species of Collembola, *Paronella sp.* (Table 1). In the freshwater swamp forest, 4
75 Cryptostigmata (*Oribatida*) species - *Opiida sp.*, *Galumnida sp.*, *Cephalid sp.*,
76 *Scheloribates*, 1 Mesostigmata (*Gamasida sp.*) were collected (Table 2).

77 In lowland rain forest - Warri North LGA (1), 4 species of Cryptostigmata (*Oribatida*) -
78 *Archeogozettes magnus*, *Galumnida sp.*, *Cephalid sp.*, *Scheloribates sp.*; 2 species of
79 Mesostigmata (*Gamasida*), *Asca sp.* and *Uropodida sp.* and 1 species of Collembola -
80 *Paronella sp.* were collected (Table 3). In lowland rainforest of Warri South LGA, 4
81 Cryptostigmata (*Oribatida*) - 4 species *Scheloribates sp.*, *Galumnida sp.*, *Cephalida sp.*,
82 *Opiida sp.*; 2 Mesostigmata (*Gamasida*) - *Asca sp.*, *Uropodida sp.*, and 1 Collembola *sp.*-
83 *Paronella sp.* were collected (Table 3).

84 DISCUSSION

85 In the lowland rainforest, the species composition of mites and Collembolans was more
86 limited than that of Okiwelu *et al.* (2011) from undisturbed habitat in lowland rainforest of
87 eastern Niger Delta. This was probably due to the significantly reduced period for
88 collection. The absence of any Prostigmata *sp.* was also probably due to the limited
89 collection period. However, both monitor species of Cryptostigmata (*Galumnida sp.*;
90 *Scheloribates sp.*) and indicator species of Cryptostigmata (*Cephalides sp.*, *Archeogozettes*
91 *magnus*, *Oppia sp.*) and Mesostigmata (*Asca sp.*, *Trachyllropodida sp.*, *Uropodida sp.*)
92 were encountered. The Collembolan monitor *sp.* (*Paronella sp.*) was encountered.

93 In the mangrove swamp forest, there were six spp. that consisted of both monitor spp.
94 (*Bichrthermannia negeriana*, *Scheloribates sp.*, *Galumnida sp.*) and indicator spp.

95 Cryptostimata - (*Archegozettes magnus.*, *Cephalida sp.*) and Mesostigmata - (*Asca sp.*). The
 96 Collembolan monitor species - *Paronella sp.* was also identified. In the freshwater swamp
 97 forest, there were 2 monitor spp. - Mesostigmata (*Galumnida sp.*, *Scheloribates sp.*) and 3
 98 indicator species – (*Oppia sp.*, *Cephalida sp.*) and Mesostigmata (*Asca sp.*). In lowland
 99 rainforest, 2 monitor species- Mesostigmata (*Galumnida sp.*, *Scheloribates sp.*) and 1
 100 indicator species - Mesostigmata (*Asca sp.*) were identified. The Collembolan monitor
 101 species - *Paronella* was also identified.

102 In a series of studies in lowland rainforest, Rivers State, eastern Niger Delta (Gbarakoro *et*
 103 *al.*, 2010, 2011; Okiwelu *et al.*, 2011 a & b), it was established that a full complement of
 104 soil microarthropods of monitor and indicator species was adequate for bio-monitoring to
 105 assess ecosystem health. Monitor species are used to assess the scale and distribution of the
 106 pollutants while indicator species are sensitive to the pollutant and their presence or absence
 107 indicates a significant level of contamination. The mangrove, freshwater swamp forests and
 108 lowland rainforests of the western Niger Delta also have these complements of soil
 109 microarthropods. Oil pollution biomonitoring with soil microarthropods is therefore feasible
 110 across all eco-vegetational zones in the Niger Delta and it is thus recommended.

111 CONCLUSION

112 The full complement of soil micro-arthropod ecosystem health indicators (monitor and
 113 indicator species) were widely distributed across the major eco-vegetational zones
 114 (Lowland rainforest, Mangrove swamp forest, Freshwater Swamp forest) of the western
 115 Niger Delta. They had been found extensively distributed in the eastern Niger Delta.
 116 Consequently, their use for biomonitoring of oil pollution in the Niger Delta is feasible and
 117 advisable.

118
 119
 120 Table 1. Species of microarthropods from Mangrove Swamp Forest
 121

Vegetation type	Mites		Collembola
	Oribatida	Gamasida	
Mangrove Swamp Forest	<i>Archegozettes magnus</i> <i>Annecticarus sp.</i> <i>Bicyrthermannia nigeriana</i> <i>Cephalida sp.</i> <i>Galumnida sp.</i> <i>Scheloribates sp.</i>	<i>Asca sp.</i>	<i>Paronella sp.</i>

122
123
124
125
126

Table 2. Species of microarthropods from Freshwater Swamp Forest

Habitat type	Mites		Collembola
	Oribatida	Gamasida	
Freshwater Swamp Forest	<i>Cephalida sp.</i>	<i>Ascidae sp.</i>	
	<i>Galumnida sp.</i>		
	<i>Oppia sp.</i>		
	<i>Scheloribates sp.</i>		

127
128
129
130
131

Table 3. Species of microarthropods from Lowland Rainforest

Vegetation type	Mites		Collembola
	Oribatida	Gamasida	
Lowland Rainforest - Warri North LGA	<i>Archezogozettes magnus</i>	<i>Asca sp.</i>	<i>Paronella sp.</i>
	<i>Cephalida sp.</i>		
	<i>Galumnida sp.</i>		
	<i>Scheloribates sp.</i>		
Lowland Rainforest (Farm bush) - Warri South LGA	<i>Cephalida sp.</i>	<i>Asca sp.</i>	<i>Paronella sp.</i>
	<i>Galumnida sp.</i>	<i>Uropodidae sp.</i>	
	<i>Oppia sp.</i>		
	<i>Scheloribates sp.</i>		

132
133

REFERENCES

1341. Gbarakoro T.N., Okiwelu S.N., Badejo M.A., Umeozor O.C. 2010. Soil microarthropods in
135 a secondary rainforest in Rivers State, Nigeria -I- Seasonal variations in species richness,
136 vertical distribution and density in an undisturbed habitat. *Scientia Africana* 9:48-54.
1372. Bardgett R.D. 2002. Causes and consequences of biological diversity in soil. *Zoology* 105:
138 367-374.
1393. Fountain M.T., Hopkins S.P. 2005. *Folsornia candida* (Collembolan): a standard soil
140 arthropod. *Annual Review of Entomology* 50:201-222.
1414. Seastedt T.R. 1984. The role of microarthropods in decomposition and mineralization
142 processes. *Annual Review of Entomology* 29:25-46.

1435. Tian G., Adejuyigbe C.O., Adeoye G.O., Kang B.T. 1998. Role of soil microarthropods in
144 leaf decomposition and N release under various land-use practices in the humid tropics.
145 *Pedobiologia Jena* 42:33-42.
1466. Okiwelu S.N., Gbarakoro T.N., Badejo M.A. 2011a. Soil microarthropods in a secondary
147 rainforest, Rivers State: Ecosystem health indicators of oil pollution. *Journal of Ecology*
148 *and Natural Environment* 3:29-32.
1497. Gbarakoro T.N., Okiwelu S.N., Umeozor O.C., Badejo M.A. 2011. Soil microarthropods in
150 a secondary rainforest -III- partial recovery after an oil spill. *International Journal of*
151 *Ecosystem* 1: 1-4.
1528. Badejo M.A. 1996. Measuring the diversity of soil microarthropods and microfauna in an
153 area of conservation of biodiversity. *In* Biosphere resources for diversity conservation and
154 sustainable development in Anglophone Africa (BRAAF), Assessment and monitoring
155 techniques in Nigeria, Abeokuta, Nigeria, 120pp.
1569. Okiwelu S.N., Gbarakoro T.N., Umeozor O.C., Badejo M.A. 2011b. Soil microarthropods
157 in a secondary rainforest, Rivers State, Nigeria -IV- the impact of oil pollution on their
158 distribution. *Resources and Environment* 1:1-4
15910. Martin M.H., Coughtrey P.J. 1982. Biological monitoring of heavy metal pollution.
160 *Pollution monitoring series Ad.* (Mellanby K., ed.). Applied Sciences Publishers Ltd.
161 London 475pp.

162

163