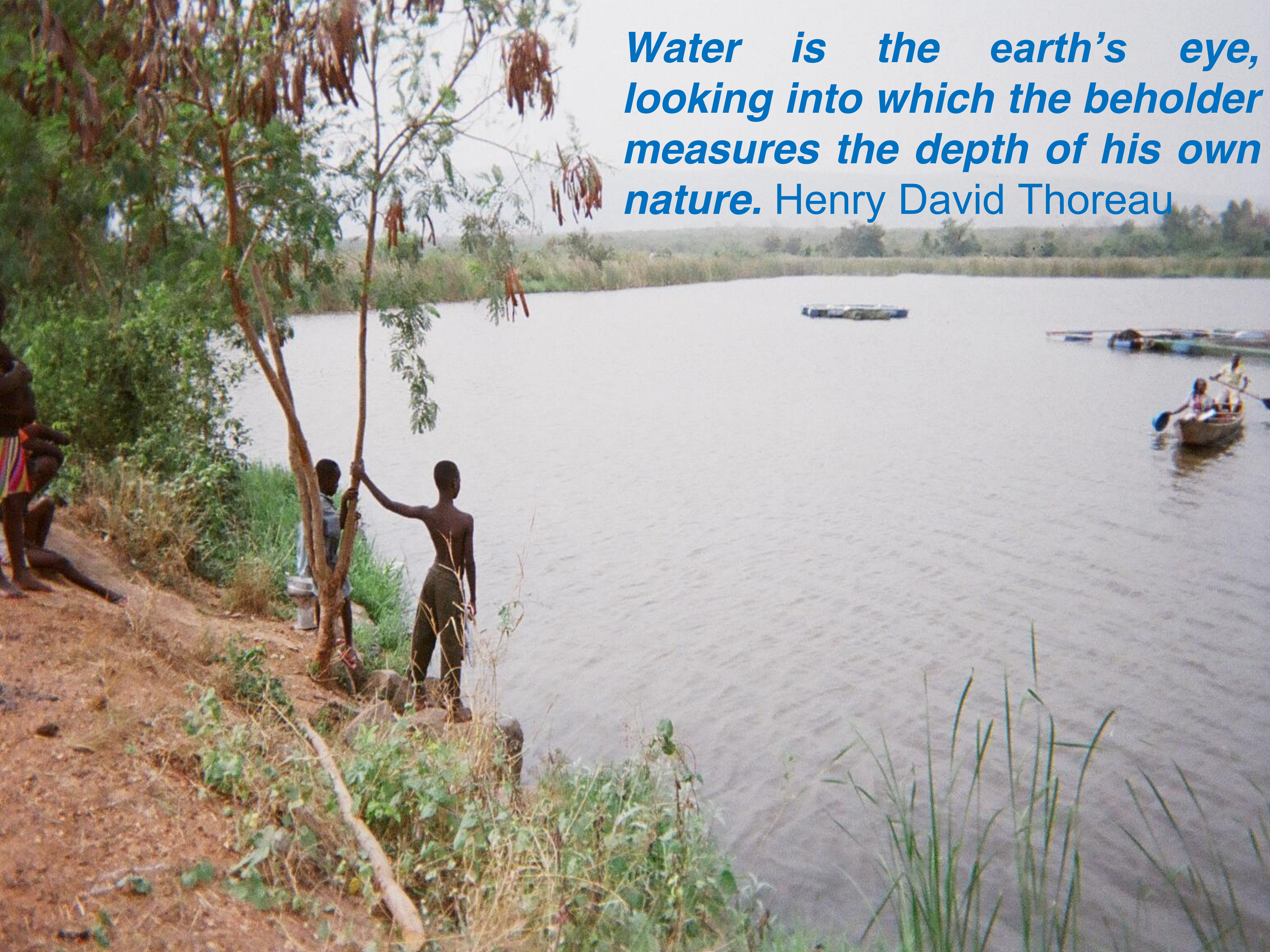

Water is the earth's eye, looking into which the beholder measures the depth of his own nature. Henry David Thoreau

Outline

I. Background

II. Objective

III. Methodology

IV. Results

V. Conclusions

VI. References

VII. Acknowledgements

Environmental Pollution in Densu Estuary,Ghana

Akita, L.G.,[1] Mahu, E.,[1] Akrong, M.O.,[2] Alivernini, M.,[3] Frenzel, P.J.,[3] Banu, R.A.,[2] Klubi, E.,[1] Biehl, T.,[3] Biehler, J.,[3] Laudien, J[4]., Appeaning-Addo, K.[1]

[1]University of Ghana, Ghana
[2] CSIR-Water Research Institute, Ghana
[3] Friedrich-Schiller University Jena, Germany
[4] Alfred-Wegner Polar Institute of Marine Science, Germany

Coastal Ocean Environment Summer School in Ghana, 30th July to 4 August 2018, Venue: University of Ghana

Organizers: University of Michigan-University of Ghana

I. Background

- Exponential increases in pollution of inland and coastal water bodies

- Disposal of untreated waste and solid waste into water bodies

- Extensive over-exploitation of resources → habitat degradation

I. Background: Why coastal monitoring?

Agbloboshie in **Ghana's capital Accra** has been ranked in the top 10 most polluted places in the world, thanks to toxic fumes, which are a result of consistent dumping of electronic goods.

Source: E-waste, pollution plagues Accra's Agbloboshie | West Africa

www.theafricareport.com 17.06.2014

Pollution in Accra, Ghana

Air Pollution	87.50
Drinking Water Pollution and Inaccessibility	91.67
Dissatisfaction with Garbage Disposal	100.00
Dirty and Untidy	91.67
Noise and Light Pollution	93.75
Water Pollution	100.00
Dissatisfaction to Spend Time in the City	91.67
Dissatisfaction with Green and Parks in the City	100.00

www.numbeo.com 17.06.2014

Water Pollution causes 14, 000 death per day

http://www.ghananewsagency.org/science/water-pollution-caus
14-000-deaths-per-day-61736

I. Background: Why coastal monitoring?

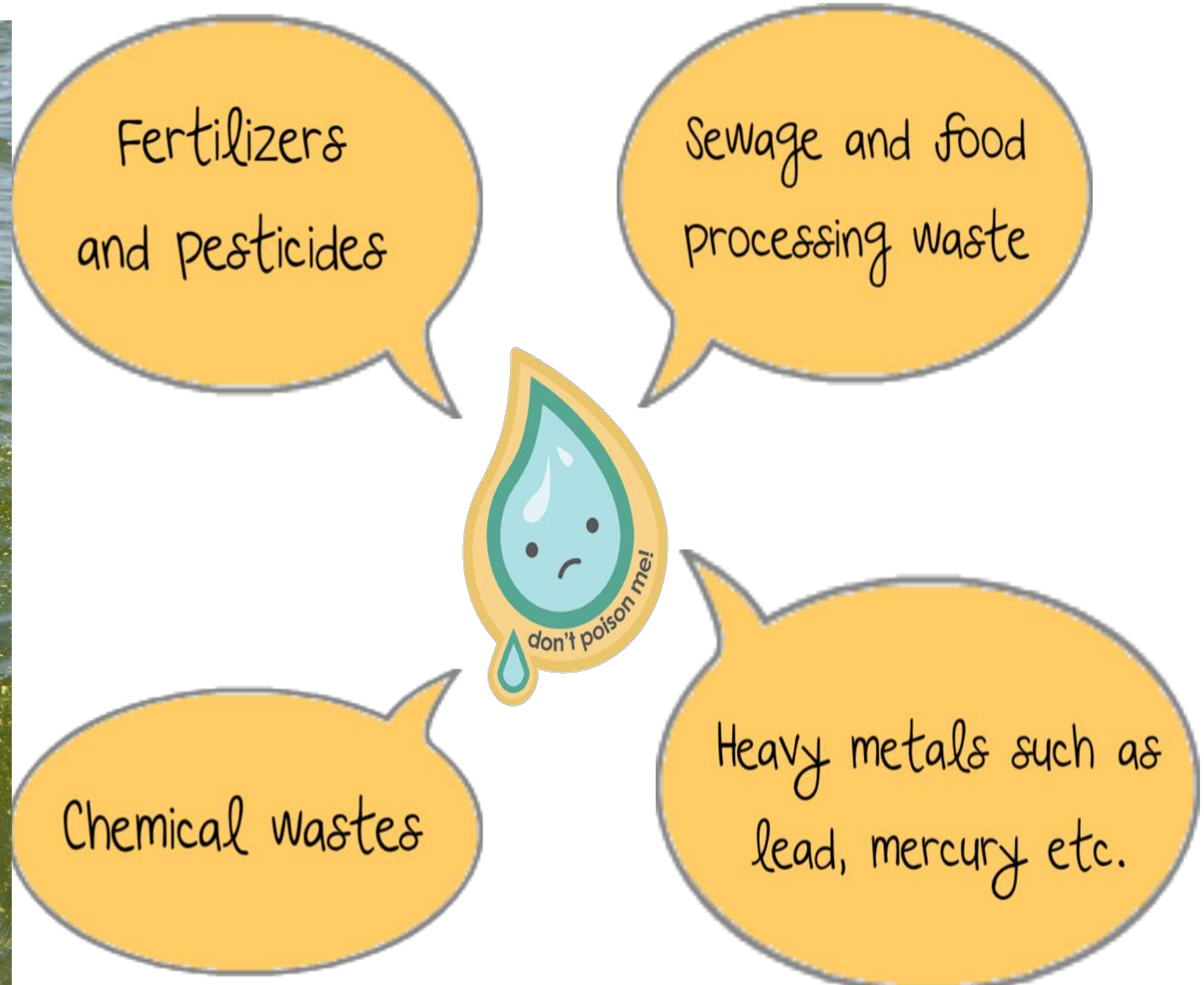
- Marine and coastal ecosystems – local economies (Sindermann, 2005) (e.g., coastal development , agricultural and urban waste, fisheries)

- Changes in the ecosystems – anthropogenic disturbances (e.g., pollution, land use changes) or natural stressors

- All species tolerate a limited range of environmental variables (Holt & Muller, 2010)

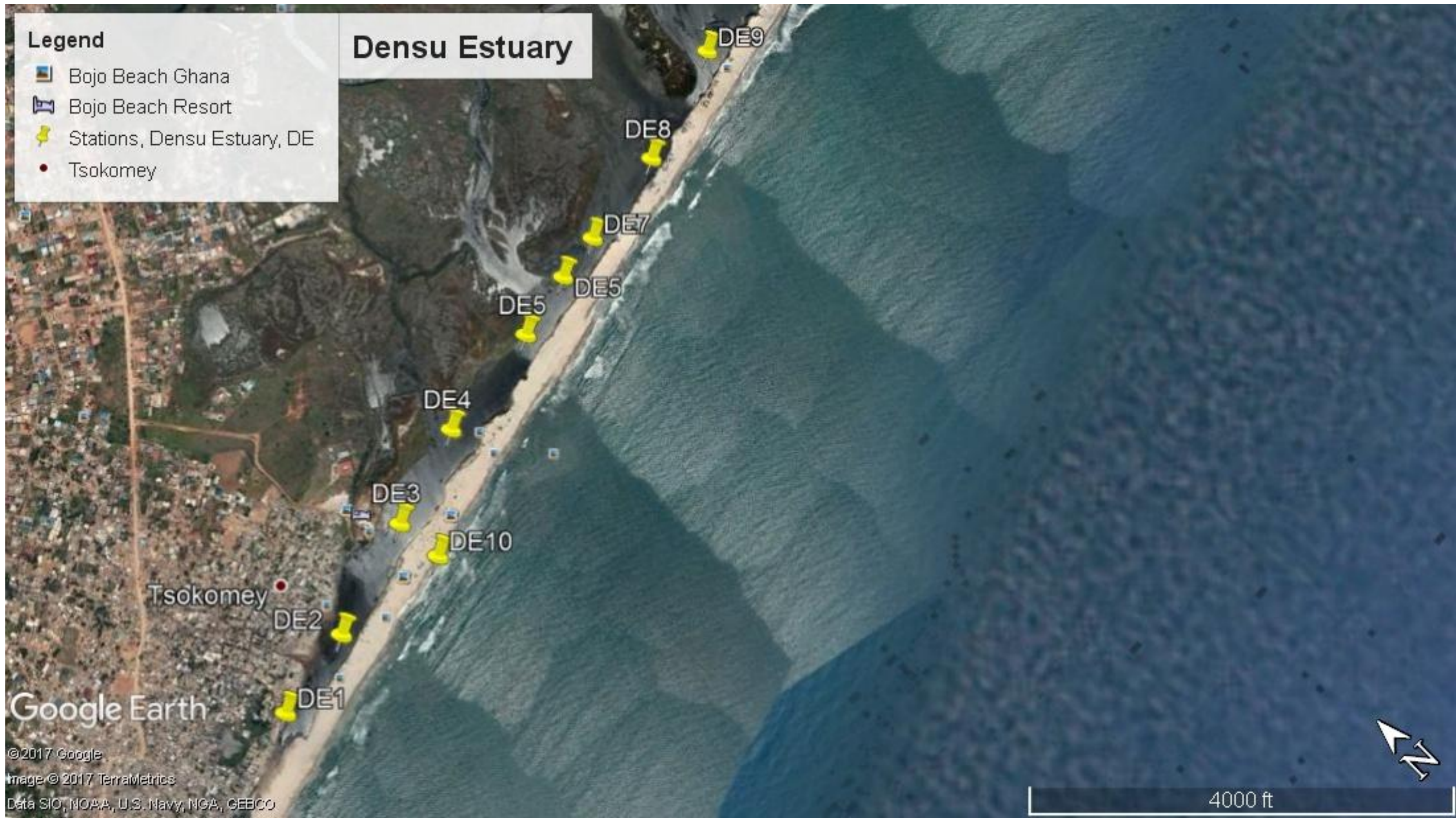
- Coastal water quality – sensitive organisms (e.g., benthos) with specific tolerances

Water pollution



http://celikpolisium.blogspot.ug/

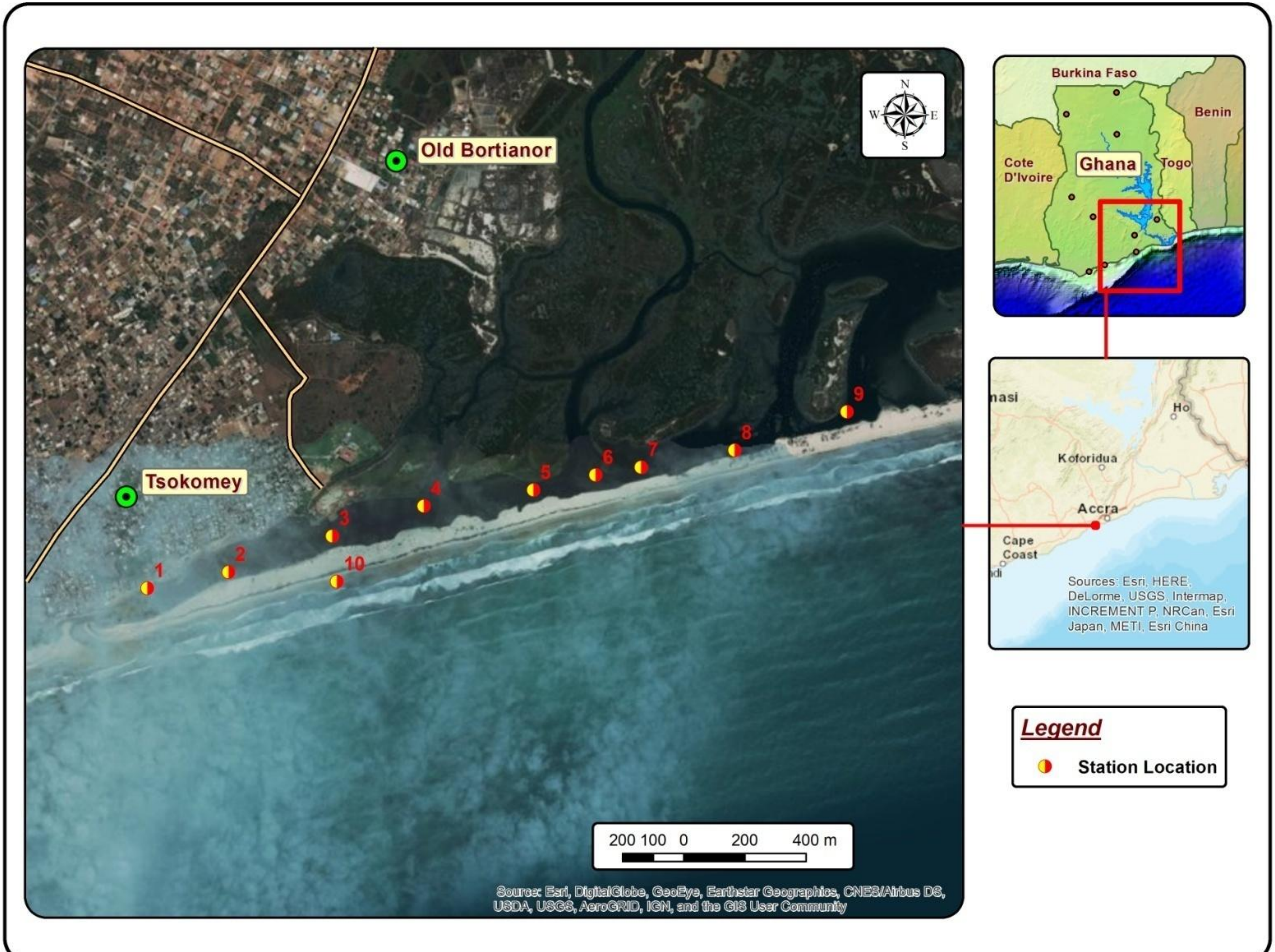
II. Densu Estuary



The Densu Estuary lies between latitude 5º 30' N to 6 º 20' N and longitude 0 º 10' W to 0 º 35' W

Objective:

- **Assessment of environmental quality of Densu estuary**



Old Bortianor
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N
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E
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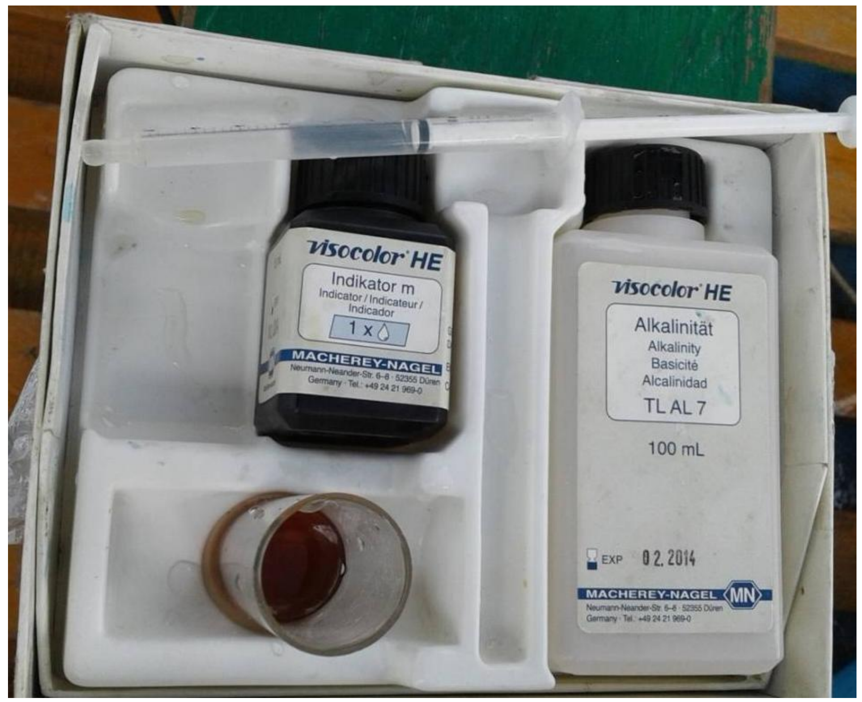
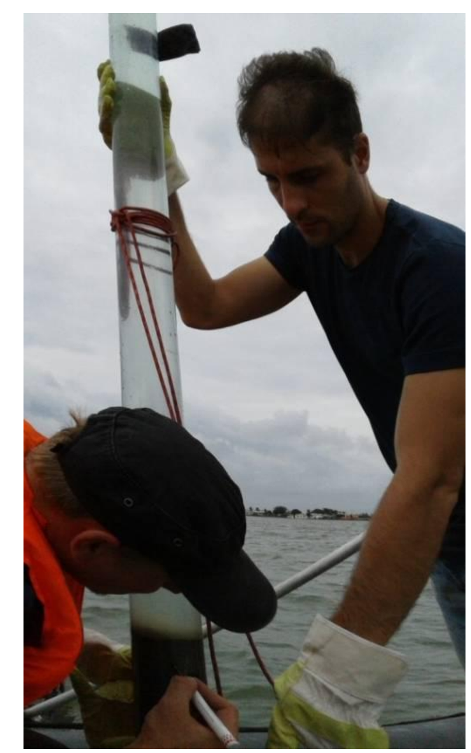
Burkina Faso
Benin
Cote D'Ivoire
Ghana
Togo
nasi
Ho
Koforidua
Accra
Cape Coast
Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China
Legend
Station Location
200 100 0 200 400 m
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

III. **Methodology: Sampling gears**





III. Methodology: Statistical Analysis

- PAST (Hammer et al., 2001) – environmental factors driving the distribution of taxa
- Hammer, Ų., Harper, D.A.T., Ryan, P.D. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4(1): 9pp.
- http://palaeo-electronica.org/2001_1/past/issue1_01.htm

IV. Results

Parameters	N	Min	Max	Mean	Stand. dev
Temp [°C]	10	30.74	34.10	32.17	0.95
pH	10	8.31	8.39	8.35	0.03
EC [mS/cm]	10	35.80	52.60	43.85	5.54
Sal	10	22.80	34.70	28.31	4.03
DO [mg/l]	10	6.44	18.81	10.48	3.27
DO Sat [%]	10	109.60	301.70	171.24	50.18
TDS [g/L]	10	21.90	31.60	27.18	3.33
TSS[mg/l]	10	18.00	38.00	23.60	6.70
Alk[mmol/l]	10	3.20	3.90	3.66	0.24
PO3-4 [mg/l]	10	0.05	1.10	0.33	0.29
NO-3 [mg/l]	10	1.70	7.50	2.98	1.74
SO2-4 [mg/l]	10	15.00	37.00	25.10	7.20
Chl A [µg/l]	9	0.96	4.38	2.25	1.32
% OC	10	0.49	2.05	1.28	0.51
% TN	10	0.06	0.15	0.09	0.03
% C:N	10	8.00	34.81	16.33	9.42
%TP	10	0.44	1.38	0.70	0.31
%SOM	10	0.85	3.53	2.20	0.89
% LOI	10	1.12	1.71	1.51	0.21
Zn (mg/kg)	10	7.30	158.30	46.93	45.01
Pb (mg/kg)	10	1.90	84.70	50.88	24.33
Hg (mg/kg)	10	0.01	0.05	0.02	0.01
% Sand	10	53.00	87.00	62.30	9.25
% Silt	10	10.00	41.00	33.60	8.96
% Clay	10	2.00	8.00	4.10	2.08
E.coli_w [cfu	10	0.00	4400.00	560.00	1360.72
Ent.spp_w [cf	10	0.00	2200.00	330.00	702.46
E.coli_s [cfu/	9	0.00	3.00	1.67	1.32
Ent.spp_s [cf	9	0.00	46.00	6.56	15.14

IV. Water Quality Index:

- **Water Quality Index** ⇨ **single** number like **grade** that expresses the overall water quality at a certain area and time based on **several water quality parameters** (Ramakrishnaiah, 2009).

- The **computed WQI values:**
- classified as <50 = Excellent; 50-100 = Good; 100-200 = Poor; 200-300 = Very poor; >300 = Unsuitable (Ramakrishnaiah et al., 2009).

- **Densu Estuary (WQI)** = 416 ± 44.06 (Mean+ SD)

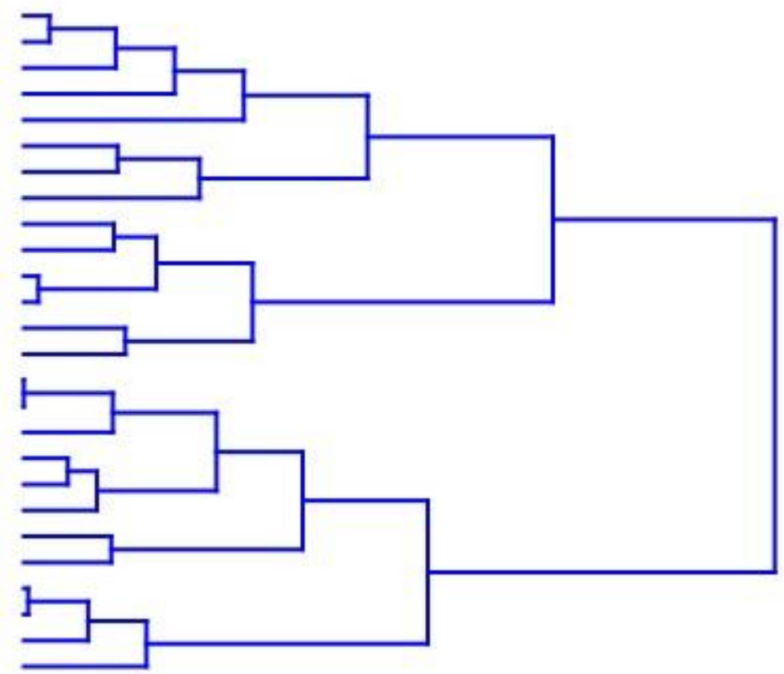
Other ecological Indicators

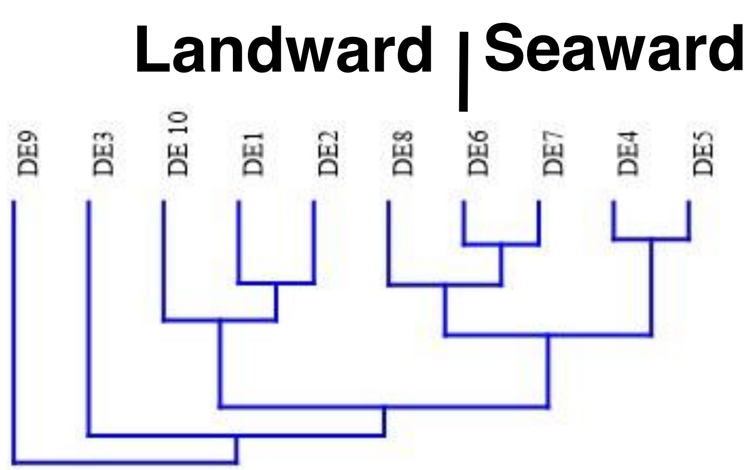
- The concentrations of heavy metals in the sediment followed the trend Zn >Pb> Hg with Cd below detection.

- Faecal bacteria (e.g., *E. coli* and *Enterococcus sp).*

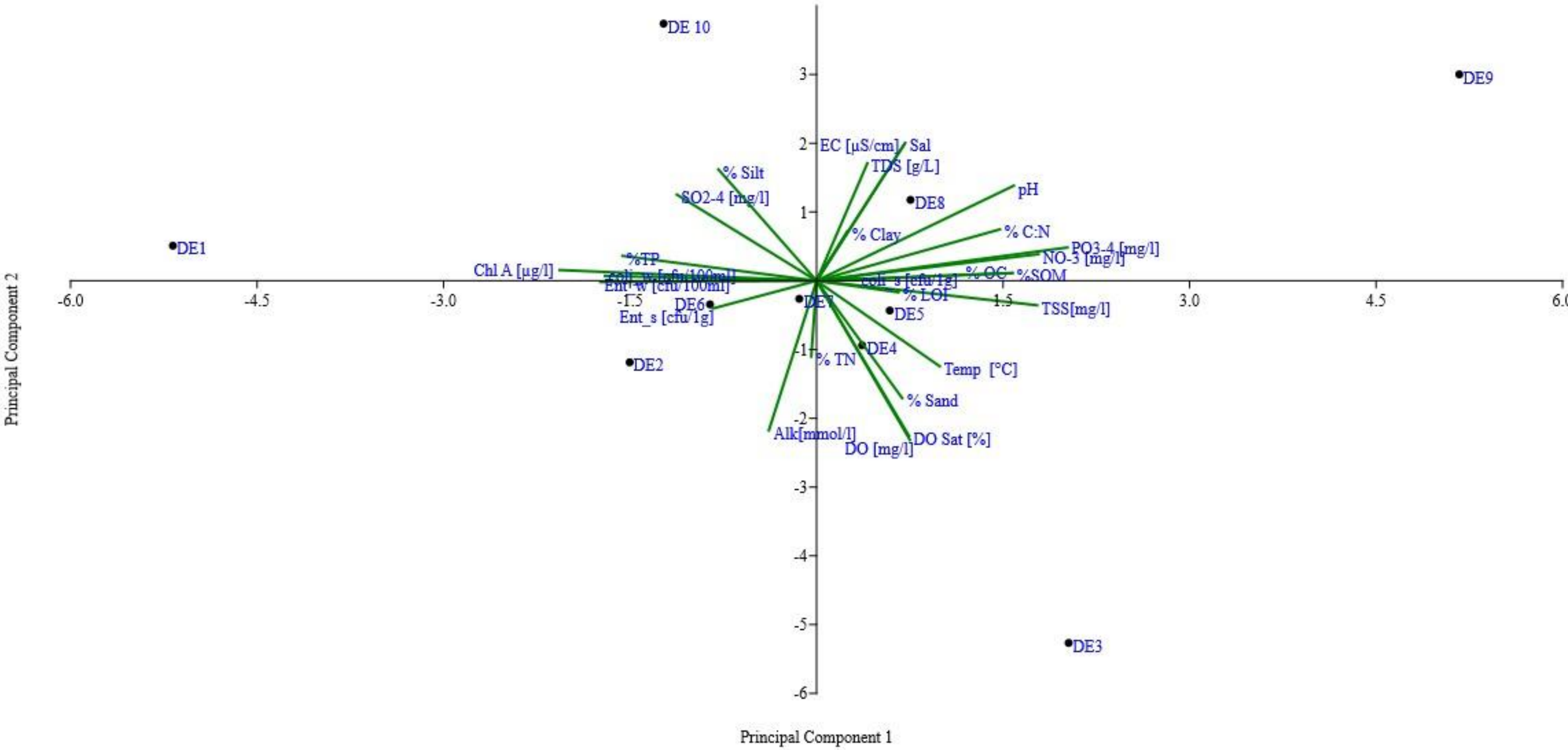
IV. Results : Cluster Analysis

-0.4698	-0.3274	-0.4698	2.662	0.6691	-0.1851	-0.4698	-0.4698	-0.4698	-0.4698	Ent_w [cfu/100ml]
-0.4115	-0.2646	-0.3381	2.822	0.0294	-0.3381	-0.4115	-0.4115	-0.3381	-0.3381	coli_w [cfu/100ml]
-0.8326	0.2407	1.249	2.225	-0.6049	-0.3447	-0.735	-0.7676	-0.3447	-0.08456	%TP
-0.01388	0.8469	0.6803	1.652	-0.4304	0.8191	-0.01388	0.8191	-1.402	-1.263	SO2-4 [mg/l]
0.2194	-2.621	0.06004	0.6943	-0.2275	-0.04991	0.5951	0.6277	0.8732	-0.1709	% Silt
-0.4329	-0.4329	-0.4329	0.2275	2.605	-0.4329	-0.4329	-0.3009	-0.3669	-0.4329	Ent_s [cfu/1g]
-1.702	-0.977	0.6733	1.615	1.426	-0.7462	-0.5631	-0.7462	0.03691	-0.719	Chl A [µg/l]
0.252	0.252	1.008	-1.26	1.008	-1.26	1.008	-1.26	0.252	-1.26	coli_s [cfu/1g]
-0.8589	1.374	-0.773	0.08589	0.3436	1.89	-0.773	0.3436	-0.6871	-0.9448	% TN
-0.3473	2.673	-0.251	-0.5974	0.1006	0.3178	-0.2958	-0.3678	-0.9474	0.2851	% Sand
-0.3754	2.6	-1.228	-0.6185	0.0829	-0.1562	0.1008	0.1347	-0.3156	-0.224	DO Sat [%]
-0.4399	2.551	-1.236	-0.7613	0.3132	-0.2042	0.1142	-0.07867	0.146	-0.1123	DO [mg/l]
-1.099	1.014	-1.944	0.169	0.5916	-1.099	0.5916	0.5916	0.5916	0.5916	Alk[mmol/l]
-0.02518	0.7618	-1.505	-1.326	-0.3295	-0.09863	0.4365	2.021	0.04827	0.01679	Temp [°C]
1.498	0.2436	-1.011	-0.4945	-0.5683	1.203	-1.528	-0.6421	0.834	0.465	%SOM
1.498	0.2436	-1.011	-0.4945	-0.5683	1.203	-1.528	-0.6421	0.834	0.465	% OC
1.963	-0.6018	-0.4267	-0.5206	-0.6656	-0.3774	-0.884	-0.7067	1.079	1.141	% C:N
2.596	0.5859	-0.2183	-0.6778	0.06893	0.7353	-0.3332	-0.7353	-0.448	-0.1034	NO-3 [mg/l]
2.662	0.2919	-0.5667	-0.9444	-0.3263	-0.2232	-0.2576	-0.2232	0.1545	-0.5667	PO3-4 [mg/l]
2.148	1.104	-0.8354	-0.8354	0.6564	-0.2387	-0.8354	-0.2387	-0.2387	-0.6862	TSS[mg/l]
0.5799	-0.7955	0.8068	-0.2491	0.4773	-1.124	-1.112	-0.9416	0.5013	1.858	% Clay
0.9106	0.9554	0.8374	-0.05167	0.3928	-1.915	-0.8725	-0.9427	0.7729	0.6978	% LOI
1.386	-0.8208	1.585	-0.548	-0.5976	0.9398	-0.07687	0.1711	-1.366	-0.672	Sal
1.381	-0.7493	1.58	-0.4966	-0.6049	0.9299	-0.09931	0.1535	-1.454	-0.641	EC [µS/cm]
1.146	-0.9538	1.326	-0.6239	0.8758	0.8159	-0.2939	0.06599	-1.584	-0.7739	TDS [g/L]
1.499	-0.8073	0.346	-1.576	-1.192	1.115	0.346	0.7304	-0.4229	-0.03844	pH





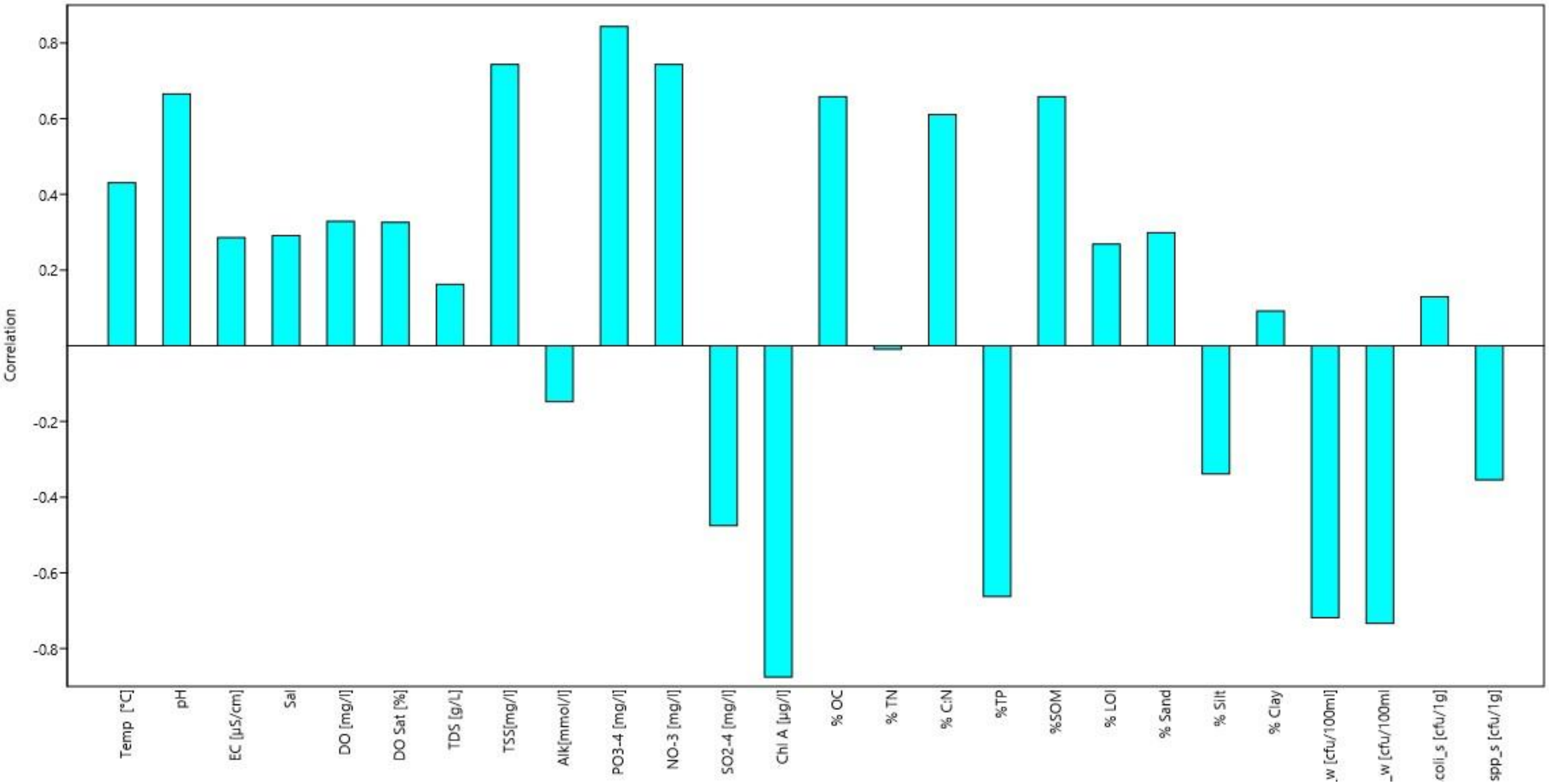
IV. Results: Principal Components Analysis



Productivity (27.0%)

Marine Influence (23.5%)

IV. Results: Correlation



V. Conclusion

- Metals in soil **[mg/g]**: Zn-76.80 to 158.30, highest **S1**; Pb-84.70 to 35.10, highest **S5**; Hg-0.029 to 0.045 highest **S1**.
- Organics **[%]** in sediment: C; 0.76 to 2.05 with highest **S9**, TN; 0.06 to 0.015; C:N; 12.31 to 34.81, highest **S9**); TP; 0.44 to 1.38, highest **S1**).
- The bacterial count (highest **S1 and S2**) in water (*E. coli*; 4400 CFU/100ml and *Enterococcus sp*; 2200 CFU/100ml) was significantly higher than in sediment (2 CFU/g and 46 CFU/g) than in water.
- These types of microbes indicate faecal pollution, which can pose human health risks. Contaminated sites (S1 and S2) were influenced by anthropogenic activities.
- The use of **multiple indicators** is useful for the detection of different sources of contamination, water pollution and environmental stresses in Densu estuary, Gulf of Guinea coast, Ghana.

Recent brackish water Ostracoda and Foraminifera of Ghana – first results from Densu Estuary

FRIEDRICH-SCHILLER-UNIVERSITÄT JENA

Peter Frenzel[1], Johannes Biehler[1], Mauro Alivernini[1] & Lailah Gifty Akita[2]

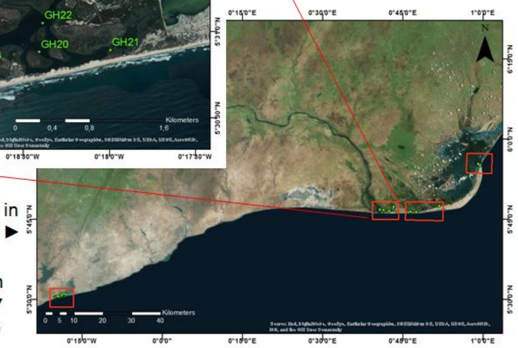
[1]Institute of Geosciences, University of Jena, Germany

[2]Institute of Marine and Fisheries Sciences, University of Ghana

UNIVERSITY OF GHANA

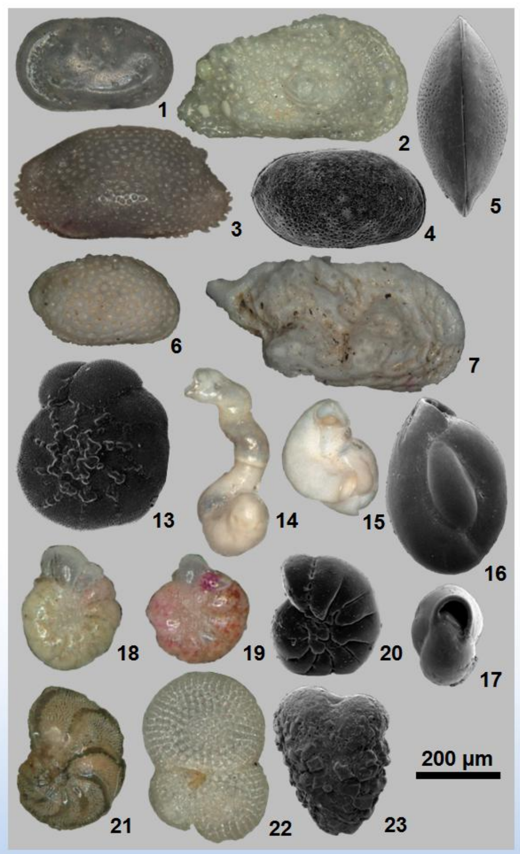
In order to calibrate Ostracoda and Foraminifera, two classical microfossil groups in geosciences, for applications in water quality monitoring and palaeoenvironmental reconstructions, we started to document their diversity, to map their Recent distribution and to collect ecological data in Ghanaian coastal waters. Most data are available from Densu Estuary so far. The brackish foraminifer fauna is composed of cosmopolitan species commonly found in either South or North African coasts. But the Ostracoda differ remarkably in species inventory although it is similar to North African faunas. A future faunistic and ecological synopsis of Ostracoda and Foraminifera of Ghanaian brackish waters, West Africa, is intended to contribute to the national and international biodiversity database.

Sampling sites in Densu ▲ Estuary



Study areas in March 2017 ►

SEM and light microscope pictures of typical 1) ◄ marine and marine-brackish taxa found in polyhaline waters and 2) ▼ brackish water taxa found in mesohaline waters of Densu Estuary



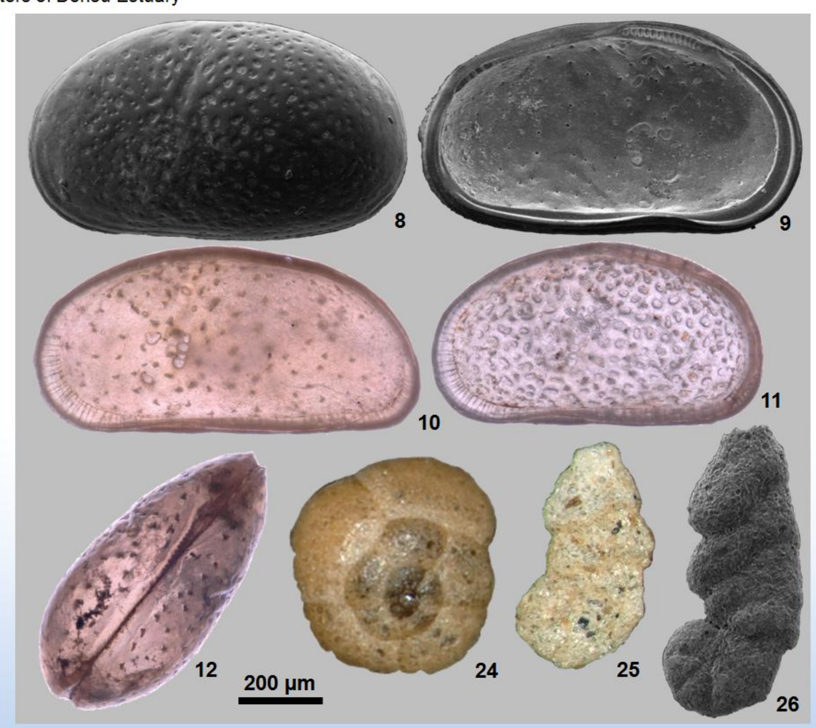


Fig. 1-12 Ostracoda: 1) *Cytherella* sp., left valve, external, GH14; **2)** Trachyleberidinae gen. et sp. inc., right valve, external, GH24; **3)** *Neonesidea* sp., left valve, external, GH14; **4-5)** *Loxoconcha* sp. 1, right valve, external, and carapace, dorsal, both GH24; **6)** *Loxoconcha* sp. 2, right valve, external, GH14; **7)** *Paracytheridea luandensis* Hartmann, 1974, right valve, external, GH14; **8-12)** *Cyprideis nigeriensis* Omatsola, 1970, 8/9/11) female left valves external, internal and in transmitted light, 10/12) male left valve in transmitted light and carapace dorsal, GH17 and GH24

Fig. 13-26 Foraminifera: 13) *Rotalinoides gaimardi* (d'Orbigny in Fornasini, 1904), spiral, GH24; **14-17)** Miliolinae, 14/15) malformed specimens, 16/17) *Quinqueloculina* sp., lateral and apertural, GH24; **18-20)** *Cribroelphidium sandiegoense* (Lankford, 1973), lateral, 19) malformed, GH24; **21)** *Hyalinea balthica* (Schröter in Gmelin, 1791), umbilical, GH24; **22)** allochthonous planktic foraminifer, GH14; **23)** *Textularia* sp., lateral, GH24; **24)** *Trochammina inflata* (Montagu, 1808); **25-26)** *Ammotium salsum* (Cushman & Brönnimann, 1948), lateral, GH24

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VII. Acknowledgments: Partners

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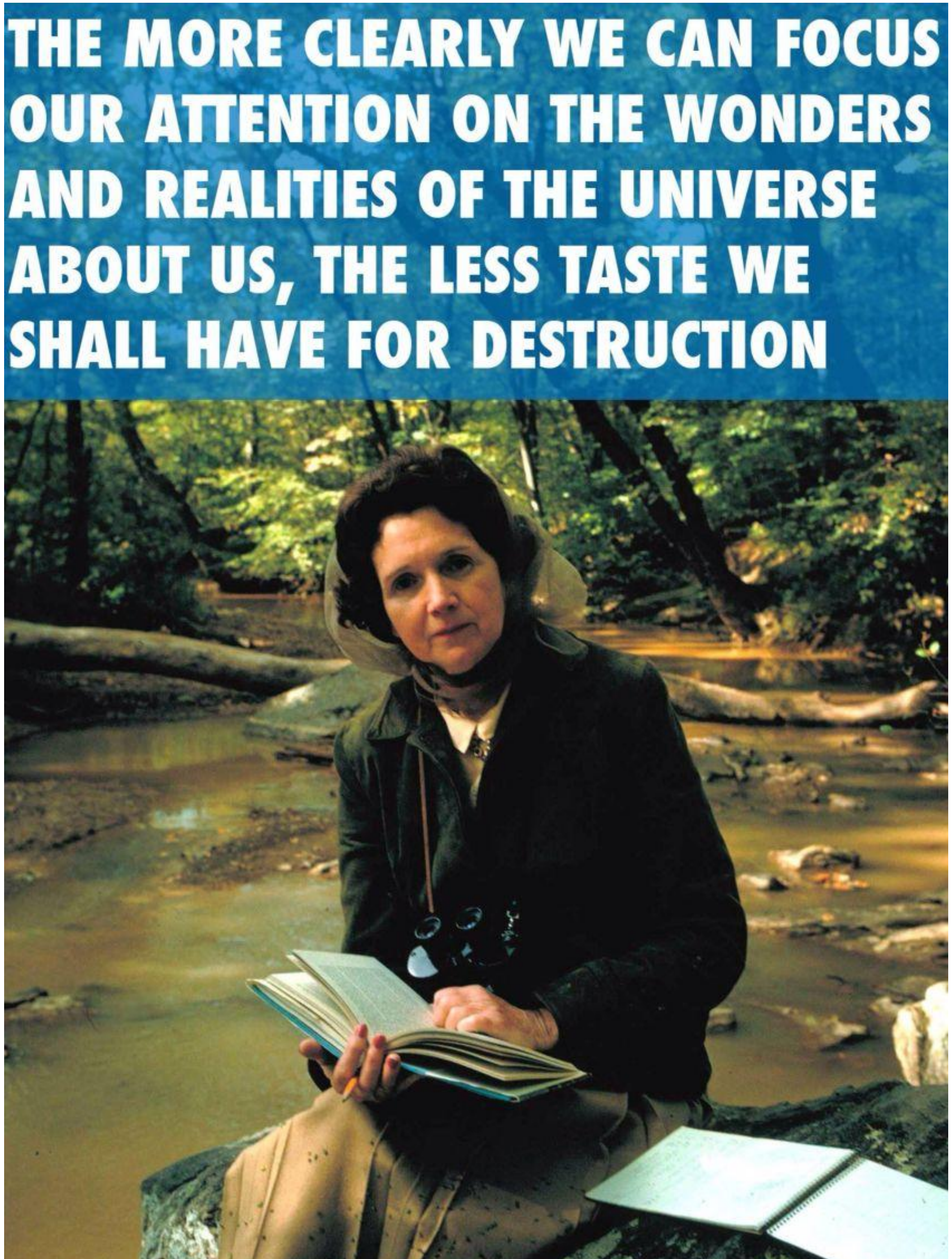
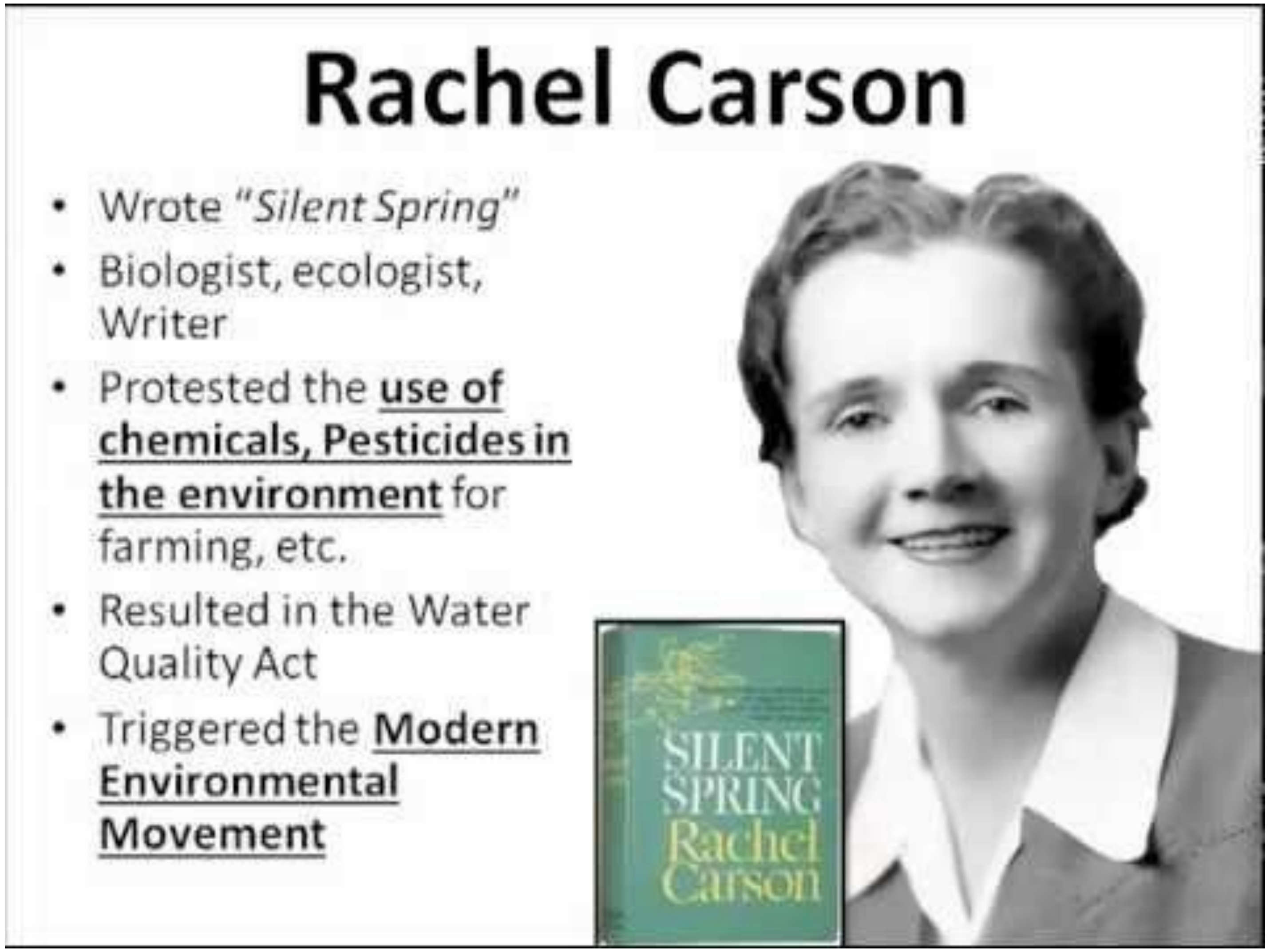
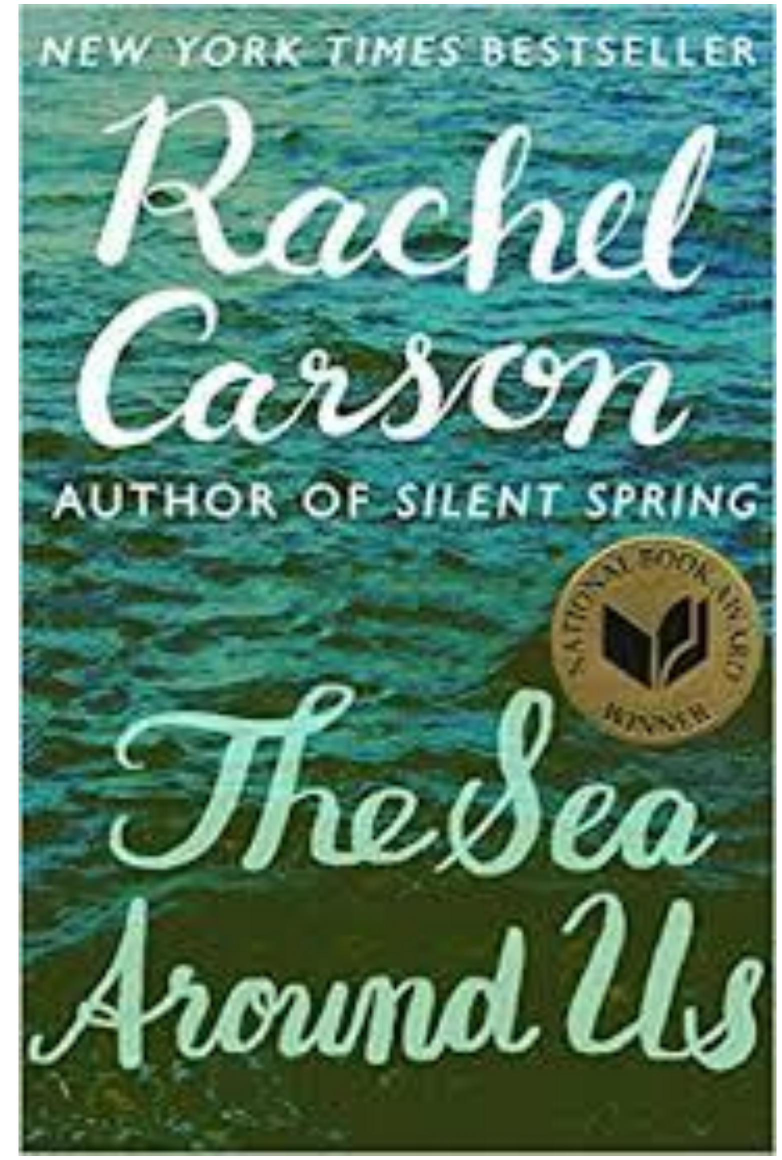

THE MORE CLEARLY WE CAN FOCUS
OUR ATTENTION ON THE WONDERS
AND REALITIES OF THE UNIVERSE
ABOUT US, THE LESS TASTE WE
SHALL HAVE FOR DESTRUCTION


"The road we have
long been traveling
is deceptively easy,
a smooth superhighway
on which we progress
with great speed,
but at its end lies disaster.
The other fork of the road –
the one 'less traveled by'–
offers our last,
our only chance to
reach a destination
that assures
the preservation
of our earth."
From *Silent Spring* 1962
Rachel Carson


Rachel Carson
Wrote "Silent Spring"
Biologist, ecologist, Writer
Protested the use of chemicals, Pesticides in the environment for farming, etc.
Resulted in the Water Quality Act
Triggered the Modern Environmental Movement
SILENT SPRING
Rachel Carson


NEW YORK TIMES BESTSELLER
Rachel Carson
AUTHOR OF SILENT SPRING
NATIONAL BOOK AWARD WINNER
The Sea Around Us

Opportunities for graduates students:

- Coastal Ocean Environment Summer School in Ghana

  https://coessing.org/

- Volkswagen Foundation

  https://www.volkswagenstiftung.de/en/foundation

- PhD Program IMPRS for Global Biogeochemical Cycles

  https://www.bgc-jena.mpg.de/index.php/IMPRS/IMPRS

- NF-POGO Centre of Excellence in Observational Oceanography

  http://www.ocean-partners.org/centre-of-excellence