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Forms of Environmental Degradation in Mamu River Basin of South Eastern Nigeria.

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Abstract

Environmental degradation is a current challenge emanating from the man's quest for survival. River environment are not spared from such unwholesome development. The varying forms of environmental degradation have been studied in 5 sub basins covering the entire drainage basin. In this study, physico-chemical –cum- biological analysis covering the selected 18 water quality parameters were analyzed in dry and rainy seasons to determine their levels of concentration in the laboratory. Soil samples were also collected from the sub basins to analyze the physical properties. The result of the analysis was subjected to statistical analysis. Principal Component Analysis explained 84% of the total variation in water quality and the parameters that loaded highly were mainly metals and heavy minerals. Paired sample T' test indicated a significant difference in turbidity, dissolved oxygen, temperature, manganese and iron ($p \leq 0.05$) while total suspended solids, iron, turbidity, sulphate, temperature, magnesium, calcium, and carbon showed a positive and strong correlations in the rainy and dry seasons. Thus, the tests showed that water quality parameters respond to seasons. The result of the physical properties of the soil revealed a degraded soil orchestrating from poor aggregate stability index of less than 28.77%. Solid waste disposal, excavation of land and other forms of man's socio-economic activities have also exposed the basin more to degradation and hence posit the need for robust eco-friendly practices within the watershed.

Key words: degradation; environment; river basin; soil erosion; water pollution

INTRODUCTION

Environmental degradation affects ecological diversity. Ecological diversity is a form of biodiversity which is reflective of the density and quality of ecosystem existing in a place which could be a habitat, region or the earth; and such variation usually occurs within the terrestrial and aquatic ecosystem. Environmental degradation often times stems from man's activities geared towards survival. According to National Research Council (1992) man's activities is cardinal in altering biogeochemical system of the environment, likewise the earth as a whole. Research have shown that there are continued degradation in watersheds located in rural and urban areas, and such actions impacts negatively on basin's water quality, land area, land cover/use practices, and leaves most watersheds in critical conditions (Chukwuocha et al. 2017; Aju, 2017; Yakubu 2020 and Adegboyega et al. 2021). Mamu basin, an elongated 6^{th} order dendritic drainage basin (Ayogu et al, 2019) is equally undergoing related critical conditions and is currently being degraded.

Man's economic activities within river basins no doubt, transforms and improves living conditions in such environments, but some have tampered with the existing ecological harmony and promoted environmental degradation instead. The United Nations International Strategy for Disaster Reduction (2004) defines environmental degradation as the reduction of the capacity of the environment to meet social and ecological objectives and needs. Environmental degradation is as a result of social –economical, technological and institutional activities. Degradation occurs when earth's natural resources are depleted. Moges et al (2020) noted that unhealthy land use practices have led to degradation of watershed in the north-west highlands of Ethiopia which degenerated to serious food insecurity and poverty. Jamal et al (2016) decried the significance of degradation along the watershed of Rajasthan evidenced by decrease in forest vegetation with serious implications in scrub erosion and salinization. Similarly, Ekiye et al (2010) decried the rapid degradation of our environment with regards to river water quality in major cities across Nigeria. It is on this note that Amede et al (2020) harped on protection of soil against loss and lack of soil moisture as promising options.

Water is a compound on which almost all the activities of human on earth derives its life from but the quality of most surface water bodies have been impacted upon by wastes and erosion processes (Ayogu, et al 2019), agriculture and other anthropogenic activities. Such action leads to the alteration in the physical, chemical and biological quality due to contamination and pollution (Kevin, 2011; UNEP, 1992; USEPA, 2014; Ayogu et al 2019b). Degradations in river water have deleterious effects such as the loss of habitat value provided by river due to sedimentation (Bilotta et al, 2008), effect of industrial wastes, high organic matter decomposition and siltation of river waters (Ajibade, 2004). On the above note, Gumma et al (2021) stressed that river basin intervention practices which improves on-site soil and water environmental services being a veritable tool for sustainable land management practices should be upheld in different places.

Most environmental degradation emanate from changes in our environment, such as: urbanization, population growth, intensification of agriculture and increase in energy use (Greenliving, 2010). The degradation impacts our wild life, plants and animals and microorganism and is reflective of our ecological health or standard. This is because it is an indicator of the ecological health of man's environment from where his economic development ultimately derives (UN/National Research Council, 1992). To this end, it is imperative that the various forms of degradations in our environment be examined. This study therefore sets out to investigate the various forms of environmental degradation in Mamu Basin and their implications.

MATERIALS AND METHODS

The study Area

The study area is located within geographical grid of latitudes 6°00'N to 6°45'N and longitudes 6° 45'E and 7°30'E. It covers an aerial extent of 555.9km· Mamu basin is dominated by highlands and plains situated within the Eastern Nigeria Sedimentary basin, which is underlain by rocks of Paleocene age (Ofomata, 2002; Umeji,2002; Ayogu, et al 2008). Mamu basin falls within the tropical rainy climate (Af). Its rainfall pattern is marked by violent thunderstorm at the onset and the ending of rainy season. The intensity and duration of rainfall in the basin is usually high. The mean annual rainfall ranges between 1750mm-2050mm.It experiences seven months of effective rainfall normally from April to October and five months of dry season from November to March. The drainage basin understudy has its headwaters in Mamu Formation and Nsukka Formation respectively. Ferralitic soils and hydromorphic soils characterize the basin. The soil structure of the Mamu basin ranges from fairly consolidated to lose unconsolidated sand. The upper horizon consists mainly of coarser materials while finer particles are towards the base. The parent material of the basin soil is of sedimentary origin composed mainly of shale and sand stone.

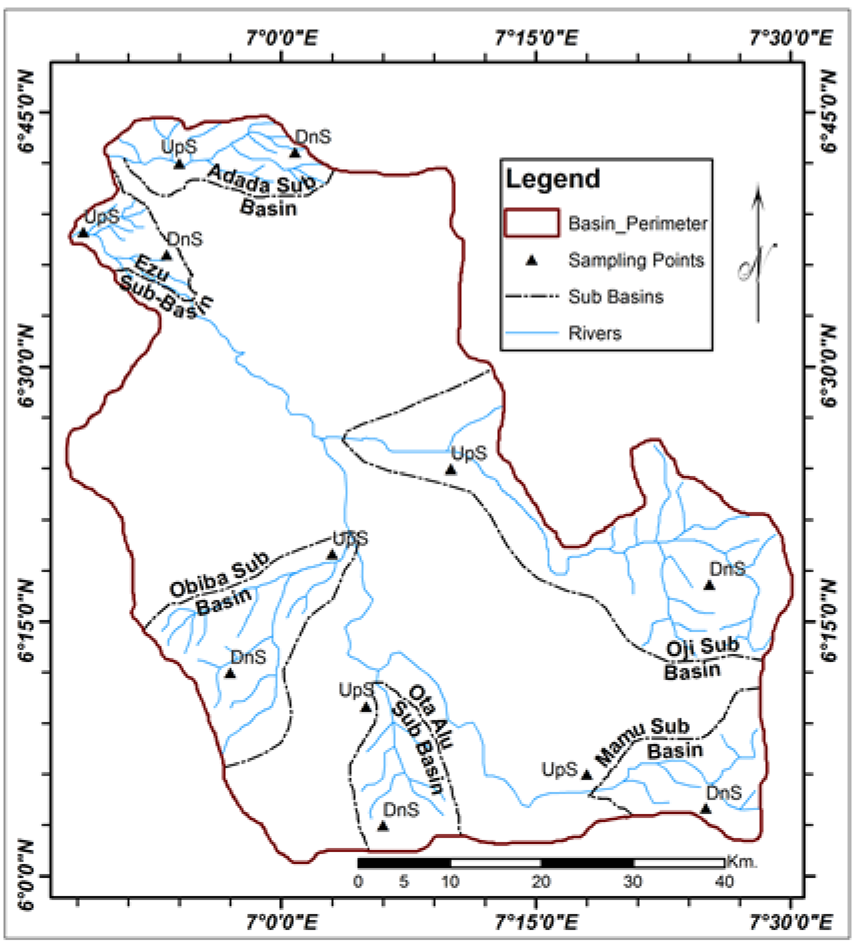

Fig. 2: The study area showing the sampled sub basins

Data Collection

Water samples were collected from the upstream and downstream segment of the river Mamu basin in the rainy and dry seasons. The samples collected were analyzed for the physico-chemical (Ph, carbon (C) calcium (Ca), magnesium (Mg), chlorine (Cl), potassium (K), nitrates (NO), phosphate (PO), zinc (Zn), iron (Fe), manganese (Mn), total dissolved solids (TDS), total suspended solids (TSS), temperature (Temp), sulphate (SO4), turbidity) and biological parameters (dissolved oxygen (DO), Bio -chemical Oxygen Demand) (BOD), in the laboratory while the temperature and the dissolved oxygen were determined in-situ following the custody of practice.

As regards the soil analysis, the Particle size distribution, textural class and aggregate stability of soils in the Mamu basin were used to ascertain the detachability of the soils. The analysis conducted in the laboratory revealed the stability indices as well as the soil textural class following Gee and Or (2012).

RESULTS

Table1 shows the result of the water quality analysis, wet season and dry seasons were subjected to Principal Component Analysis for clearer explanations of the variable factors (Table 2 and 3). PCA explained 88.20% and 85.44% of variation in rainy and dry season respectively.

Table 1: Water Analysis

Parameters	Adada Upstream		Adada Downstream		Oji Upstream		Oji Downstream		Ota-Alu Upstream		Ota-Alu Downstream		Obibia Upstream		Obibia Downstream		Mamu Main Channel Upstream		Mamu Main Channel Downstream		Ezu Upstream		Ezu Downstream	
	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S	R/S	D/S
Ph	6.8	5.7	5.9	6.2	6.3	5.4	6.4	5.1	5.9	5.3	5.6	6.2	5.6	6.8	6.1	6.2	6.2	6.8	5.7	6.2	6.4	6.6	6.3	6.9
C	10.01	24.3	34.93	36.85	20.01	10.01	114.73	60.5	19.95	0.01	0.01	40.5	24.3	89.77	9.97	10.02	79.5	56.5	64.7	90.24	98.16	112.4	105.4	111.418
Ca	8.01	3.21	40.08	42.1	40.08	41.0	16.03	6.1	5.61	6.01	40.08	60.41	40.08	40.1	10.42	8.02	10.99	15.5	8.6	12.80	12.10	30.1	23.9	32.5
Mg	43.64	48.78	63.23	24.32	34.04	38.91	48.64	24.32	97.28	19.46	24.32	34.05	1045.76	1072.76	72.96	38.91	102.64	54.6	34.05	46.03	168.19	178	110.2	120
Cl	0.51	6.24	3.22	5.24	0.01	6.07	9.55	11.5	3.17	8.34	0.01	7.21	10.45	10.51	1.59	7.68	10.5	17.4	88.6	5.6	19.9	11.3	12.5	3.6
K	0.01	0.82	0.33	0.57	0.01	0.95	0.72	0.9	0.01	0.84	0.04	1.55	0.27	2.38	0.05	0.93	0.17	1.04	5.20	6.93	8.70	1.04	0.91	7.41
No	0.01	0.07	0.11	0.07	0.07	0.70	0.18	0.24	0.04	0.04	0.04	0.08	0.09	0.09	0.11	0.99	0.7	0.9	0.51	0.06	11.6	1.08	2.1	2.5

Po	0.01	2.3	0.18	0.20	0.04	0.16	0.20	0.7	0.02	0.02	0.02	0.34	0.14	10.6	0.15	0.94	0.9	2.04	0.92	1.15	0.54	0.08	0.78	2.2
Zn	0.01	0.01	2.63	6.40	0.01	0.07	1.52	3.0	0.01	0.01	0.05	6.01	2.44	3.01	0.01	0.01	2.9	3.51	5.0	7.12	16.5	2.25	8.4	10.6
Fe	0.01	0.08	0.01	0.8	0.01	0.06	0.04	0.25	0.01	0.01	0.01	0.03	0.01	0.04	0.01	0.02	0.05	0.04	0.05	0.72	0.04	0.85	0.65	1.2
Mn	0.01	2.1	0.01	7.5	0.01	0.4	0.01	7.5	0.02	0.02	0.5	2.2	0.02	6.0	0.01	2.0	0.03	0.03	0.76	0.94	0.14	0.25	0.05	0.21
TDS	501.6	567	750	774	259	277	130	140	102	102	115	95	120	132	330	350	287	290	762	800	382	400	319	349
TSS	520	720	11.5	530	77	82	38	41	45	45	47	55	87	95	92.0	101.3	64	72	2.8	39	15	22	102	115
Temp	26.6	27	25.6	26.7	26.1	26.3	24.3	24.3	26.9	26.9	26.3	26.1	25.7	26.4	23.3	24.2	25.1	25.6	26.8	27	24.4	25.1	23.6	26.5
SO4	75.2	78.7	36.8	78.7	35.0	28.8	24.9	24.9	18.43	18.43	23.08	29.41	17.08	88.03	19.6	29.8	13.5	18.7	21.6	25.8	48.6	50.1	62.4	78.0
DO	3.5	3.8	2.3	3.8	1.6	6.1	4.8	4.8	4.2	4.2	7.2	3.1	3.6	4.2	4.1	4.7	3.9	4.2	4.2	5.5	3.1	4.9	2.7	3.8
BOD	1.8	2.2	6.2	2.2	2.5	3.0	2.3	2.3	1.8	1.8	6.8	4.7	1.8	3.2	7.5	8.1	1.2	2.2	3.6	4.11	4.4	5.6	1.5	2.2
Turbidity	3.57	4.2	15.5	28.5	9.5	2.5	6.08	6.08	5.6	5.6	10	7.5	8.5	10.2	9.5	12.6	12.0	14.1	5.6	7.5	12.6	14.9	22.7	38.8

R/S=Rainy Season; D/S= Dry Season

Table 2: Rotated Component Matrix in Rainy Season

Component						
Variable	**I**	**II**	**III**	**IV**	**V**	**VI**
X1	.166	-.271	.127	.810*	.345	.118
X2	.476	.067	.655	-.036	.380	-.079
X3	-.130	-.201	-.053	-.237	-.853*	-.152
X4	.106	-.082	-.206	-.310	-.226	-.629
X5	.191	.899*	.109	-.219	.228	-.010
X6	.886*	.427	.002	-.026	.128	.088

X7	.976*	-.038	.084	.106	.016	.059
X8	.259	.541	.665	-.161	.261	-.034
X9	.902*	.105	.340	-.021	-.147	-.005
X10	.028	-.005	.909*	.195	-.148	-.101
X11	.162	.919*	.038	-.180	.186	.053
X12	.056	.743*	-.003	.302	-.146	.484
X13	-.287	-.014	-.239	.856*	-.022	-.055
X14	-.251	.576	-.480	.238	.047	-.368
X15	.219	.005	.205	.910*	-.192	.025
X16	-.059	.118	-.063	-.169	.896*	-.070
X17	.162	.045	-.248	-.180	-.128	.862*
X18	.191	-.067	.683	-.010	-.602	.168
Eigen value	**3.231**	**3.170**	**2.756**	**2.735**	**2.499**	**1.614**
% of variance	**17.948**	**17.614**	**15.314**	**15.197**	**13.882**	**8.967**
Cumulative	**17.948**	**35.562**	**50.876**	**66.073**	**79.955**	**88.922**

*   Significant loading ± 0.7

Table 3: Rotated component Matrix in Dry Season

	Component						
	Variable	**I**	**II**	**III**	**IV**	**V**	**VI**
X1		.519	.503	-.033	.56	.052	.489
X2		.805	.355	-.141	.191	-.056	.243
X3		.104	.219	-.072	.181	.831	-.013
X4		.024	.971	-.096	.078	.067	-.067
X5		-.152	.181	-.672	.236	-.475	.091
X6		.887	.086	.133	-.236	.111	-.012
X7		.399	.059	-.066	-.179	.216	.809

X8		.057	.959	-.012	.143	-.030	-.085
X9		.837	-.048	.071	.276	.374	.057
X10		.754	-.160	.321	.081	.147	.356
X11		-.202	.179	.082	.755	.064	-.244
X12		.392	-.242	.702	.075	-.288	-.034
X13		-.266	-.017	.855	.372	-.133	-.001
X14		.332	.172	.630	-.059	.237	-.530
X15		.102	.576	.652	.319	.186	.238
X16		-.132	-.080	.016	-.858	-.084	-.266
X17		-.320	-.084	-.274	-.632	-.138	.151
X18		.303	-.211	.126	.129	.740	.438
	Eigen value	**3.768**	**2.872**	**2.761**	**2.295**	**1.917**	**1.767**
	% of variance	**20.932**	**15.954**	**15.337**	**12.749**	**10.650**	**9.817**
	Cumulative	**20.932**	**36.886**	**52.223**	**64.972**	**75.622**	**85.440**

* Significant loading ± 0.7

From the result of the paired sample T-test in Table 4a & b, the concentration levels of some parameters such as turbidity (0.27), dissolved oxygen (.022), temperature (0.11), manganese (0.17) and iron (.019), had their p values < 0.05.

Table 4a Paired Samples Statistics

		Mean	Std. Deviation	coefficient of variation
Pair 1	PH(R/s)	6.1000	.36927	.10660
	PH(D/s)	6.1167	.61767	.17831
Pair 2	Turbidity (R/s	14.5500	10.16996	2.93582
	Turbidity (D/s	10.1375	5.22672	1.50882
Pair 3	BOD(R/s)	3.0667	1.99879	.57700
	BOD(D/s)	3.9008	2.01007	.58026
Pair 4	DO(R/s)	3.3333	.99848	.28824
	DO(D/s)	4.5417	1.21839	.35172
Pair 5	SO4(R/s)	30.1858	21.43463	6.18764
	SO4(D/s)	46.3017	26.69224	7.70539

Pair 6	Temp(R/s)	25.1917	1.27740	.36875
	Temp(D/s)	26.0083	.87952	.25390
Pair 7	TSS(R/s)	93.4417	138.30432	39.92502
	TSS(D/s)	159.9417	222.72356	64.29476
Pair 8	TDS(R/s)	335.2167	233.63589	67.44487
	TDS(D/s)	299.3667	216.67717	62.54931
Pair 9	Mn(R/s)	.0900	.21422	.06184
	Mn (D/s)	2.4692	2.86022	.82568
Pair 10	Fe(R/s)	.0750	.18188	.05251
	Fe(D/s)	.3417	.42610	.12300
Pair 11	Zn(R/s)	3.7417	4.79888	1.38532
	Zn(D/s)	3.5033	3.41527	.98590
Pair 12	PO(R/s)	.3133	.36418	.10513
	PO(D/s)	1.7275	2.91898	.84264
Pair 13	NO(R/s)	1.2992	3.29659	.95164
	NO(D/s)	.6183	.71526	.20648
Pair 14	Cl(R/s)	13.3342	24.49950	7.07240
	Cl(D/s)	8.3908	3.77033	1.08840
Pair 15	Mg(R/s)	153.7833	283.93092	81.96380
	Mg(D/s)	141.6783	296.83994	85.69031
Pair 16	Ca(R/s)	21.3317	14.58104	4.20918
	Ca(D/s)	22.4042	19.44160	5.61231
Pair 17	K(R/s)	1.3683	2.72736	.78732
	K(D/s)	2.1133	2.40925	.69549
Pair 18	C(R/s)	49.3033	40.61566	11.72473
	C(D/s)	53.5417	39.87124	11.50984

Table 4b Paired Samples Test/ correlation

		T	Df	Sig. (2 tailed)	Correlation	Significance
Pair 1	PH(R/s) PH(D/s)	-.072	17	.944	-.255	.424
Pair 2	Turbidity (R/s Turbidity (D/s	-2.543	17	.027	.890	.000
Pair 3	BOD(R/s) BOD(D/s)	-1.431	17	.180	.492	.104
Pair 4	DO(R/s) DO(D/s)	-2.788	17	.018	.094	.722
Pair 5	SO4(R/s) SO4(D/s)	-2.666	17	.022	.641	.025
Pair 6	Temp(R/s) Temp(D/s)	-3.051	17	.011	.688	.013
Pair 7	TSS(R/s) TSS(D/s)	-1.505	17	.160	.735	.006

Pair 8	TDS(R/s) TDS(D/s)	.617	17	.550	.603	.308
Pair 9	Mn(R/s) Mn (D/s)	-2.825	17	.017	.231	.469
Pair 10	Fe(R/s) Fe(D/s)	-2.761	17	.019	.663	.019
Pair 11	Zn(R/s) Zn(D/s)	.181	17	.860	.423	.171
Pair 12	PO(R/s) PO(D/s)	-1.663	17	.124	-.010	.975
Pair 13	NO(R/s) NO(D/s)	.758	17	.464	.360	.251
Pair 14	Cl(R/s) Cl(D/s)	.679	17	.511	-.114	.725
Pair 15	Mg(R/s) Mg(D/s)	1.322	17	.213	.995	.000
Pair 16	Ca(R/s) Ca(D/s)	-.340	17	.740	.832	.001
Pair 17	K(R/s) K(D/s)	-.824	17	.427	.262	.411
Pair 18	C(R/s) C(D/s)	.485	17	.637	.718	.009

Following the laboratory analysis of the soil samples, it was noted that the aggregate stability index of the soil samples in table 5 was as low as 28.77 while the textural class of the basin soil contained in table 6 showed that it is dominated by sand.

TABLE 5: The Aggregate Stability of the Study Area

SUB BASIN	**2mm**	**1mm**	**0.5mm**	**0.25**	**L.25**	**MwD**	**State of Aggregation**	**Aggregate stability**
ADADA	4.39	3.09	5.78	7.02	4.72		2.48	5.02
	0.59265	0.1854	0.1053	0.1053	0.0236	1.08035		
EZU	12.24	1.84	2.14	3.42	5.36		9.64	21.54
	1.6524	0.1104	0.0642	0.0513	0.0268	1.9051		
OBIBIA	2.01	3.21	2.03	.31	15.44		28.68	28.77
	0.27135	0.1926	0.0609	0.03465	0.0772	0.6367		

OJI	0.00	0.03	.28	6.58	18.11		1.00	1.00
	0.00	0.0018	0.0084	0.0987	0.09055	0.19945		
UPSTREAM MAMU MAIN CHANNEL	2.66	2.06	3.52	5.99	10.77		6.88	9.31
	0.3591	0.1236	0.105	0.08985	0.05385	0.7320		
OTA-ALU	0.29	0.46	1.28	4.67	18.13		4.88	4.65
	0.03915	0.0276	0.0384	0.07005	0.0915	0.2667		

TABLE 6: Particle Size Distribution and Textural Class of Soils in the Mamu Basin

SUB BASIN	CLAY	SILT	TOTAL SAND	FINE SAND	COARSE SAND	TEXTURAL CLASS
ADADA	5.04	8.56	81.40	12.93	76.46	Sand
EZU	17.04	14.56	14.56	27.18	41.22	Sandy loam
OBIBIA	29.04	24.56	24.56	41.74	4.66	Sand clay loam
OJI	5.04	2.56	2.56	43.1	49.3	Sand
UPSTREAM MAMU MAIN CHANNEL	5.04	4.56	4.56	23.2	67.2	Sand
OTA-ALU	5.04	4.56	4.56	47.94	42.46	Sand

DISCUSSION

From the PCA in Table 2, six orthogonal components were extracted to explain a total variance of 88.20%. Component 1 has significant loadings on variables, X6 (potassium) (.886), X7 (nitrate) (.976), and X11 (zinc) (.902). These minerals are attributed to have originated from dissolution of mineral ions and from decayed organic materials within the basin. This is because the nitrogen level increased with the potassium content and ash minerals emanating from the organic matter decay. Such decay processes serve as a reservoir for minerals which enhances high binding capacity for organic cation and organic contaminants (Oste, et al, 2002, Albiach, et al, 2001, Hernandez-Apaolaza et al, 2005, Cheng et al, 2007, Angin et al, 2012; Attamah, 2014) and the main media for nitrate turnover (Paul and Juma, 1981, Marumto et al, 1982, Mc Gill et al 1986). The increment in such minerals as cited above has a significant effect on Ph value as it causes decreases in the Ph concentration level. This reduction in Ph level according to Agin et al (2012) is attributed to the increase in organic substances and organic acids generated during the processes of organic matter decomposition and hence the quality level of the river water is affected. These variables all together have an eigen value of 4.723 and explained 42.94% of the total variance. The underlying factor in this component is dissolution, decay-cum-decomposition processes.

Component 11 has an eigen value of 3.170, a variance of 17.64% and accounts for 35.562% of the total variance. Three variables had significant loading in this column viz- X5, (chloride) (.899), X11 (manganese) (.919) and X12 (Total dissolved solids) (.743). Variable X5 is found in all natural waters mainly from parent rocks rich in alkali feldspar minerals and is responsible for saltiness of water and arises principally from the weathering of rocks. Thus, one of these two variables, X5 (chlorine) connotes the presence of polyvalent metallic ion while variable X11 (manganese) is a transition metal emanating from the dissolution of mineral ion from the parent rock through weathering processes, run off from erosion activities along the catchment of Mamu drainage basin where agricultural practices –cum- waste disposal take place. The underlying factor is therefore soil erosion and weathering processes in the drainage basin.

Component 111 has a significant loading on one variable. The variable is X10 (iron) (.909). Iron is mostly released from fertilizer application to cultivated lands, parent rock in course of repeated wetting and drying particularly under conditions of low organic content of top soil leading to precipitation of iron oxides. Percolating water from the thin top soil usually carry ion while the capillary rise of top soil together with iron precipitation which usually takes place at the upper level of water table (Nyle, 1999). Therefore, through the dissolution process, some heavy mineral is transported into the surface water. Thus, the underlying component factor is the dissolution of iron-bearing solution in the drainage basin.

Component IV: From this component, three variables loaded significantly. They are Ph (X1) (.810), TSS (X13) (.856) and SO4 (X15) (.910). These variables obtained an eigen value of 2.735% and an additional variance of 15.197% summing up to a cumulative percentage of 66.073%. Ph (X1) concerns the degree of hydroxyl ion, TSS (X13) deals with the visible substrate or the sediment carried by suspension in the water while sulphate (X15) is an oxidized sulphide, decomposition of organic matter through aerobic condition or the sulphorous precipitation or fertilizer application on soils. The high weight of Ph (X1) shows that water molecules are in contact with cations and anions which appear to be polarized in the presence of strong surface electric fields (Pripiat and Herbillion, 1971). This implies that there is replacement of metal ions by hydrogen ions in the river water and the release of the cation raises Ph of the water solution especially the alkali earth mineral- sulphate. Thus, the high weight of Ph corresponds with the high loading of TSS in that excess of Hydrogen ions gives rise to Ph values of 5 to 7 range which reduces the presence of other cations and the liberation of CO_2 by organic matter together with the presence of humic acids and fluvic acids which facilitates the weathering processes there by upholding the significant weight of TSS in the river water. Thus, the underlying component is therefore the effect of hydroxyl ion on the river water.

In Component V, two variables are of significant loading. They are calcium (X3) (.853) and dissolved oxygen (X16) (.896). Calcium (X3) is found in all natural waters mainly from parent rocks rich in calcium mineral especially carbonate and is partly responsible for hardness of water because it is a polyvalent metallic ion (Renold and Richards, 1996). It is also an aftermath of dead organics which accumulate in stream or bed rock as calcareous sediments. Dissolved oxygen (X16) facilitates aerobic condition and help in self-purification mechanism of river water by eliminating undesirable constituents that will lead to odour for instance. The underlying factor is the influence of organic activity / biotic action on the river water.

Component V1: This is highly loaded with BOD (X17) (.862). This is an indicator to the amount of oxygen required by microorganism e.g., bacteria to normalize decomposable organic matter under aerobic condition i.e., the quality of natural organic matter such as sewage and organic waste. The high weight of organic activities (anthropogenic) and its associated BOD indicates the influence of organic activities and its associated wastes in the river water.

In the dry season, principal component analysis explained 85.44% of the variation in the river water quality while 14. 56% was unexplained. From component 1, four variables were extracted thus variables X2 (Carbon) (.805), X6 (potassium) (.884), X9 (zinc) (.837) and X10 (iron) (.754). These variables are elements that emanated from weathering of rocks containing dissolved minerals from sand dominated soils or lithology particulates from eroded soils while carbon originated from dead plants and animal which formed the sedimentary structure. These metallic chemical elements have a relatively high density and toxicity at certain concentration even though they are essential for support of life. This could be attributed to dissolution and decomposition processes since they are all metals arising from natural processes i.e., associated to the natural composition of earth crust which is broken down by processes of weathering and through accelerated erosion processes, finds its way into the drainage basin coupled with the different human activities within the basin. The high weight of these heavy minerals can be accounting for low weight of BOD, DO and nitrate which is associated to organic activities. This is because heavy metals can have disastrous effect on plant by way of retardation of growth, structure damage, a decline in physiological and biochemical activities (Carter, 1996).

These minerals that occur naturally in the earth crust and through the anthropogenic activities in the basin can bio-accumulate. Thus, it can increase in concentration which can be stored in a biological organism over time compared to the chemical concentration in the environment. On the whole, the underlying factor could be associated to organic processes –cum- earth surface processes.

Component 11: In this component, phosphate (X8) (.959) and magnesium (X4) (971) had high loadings. This is an indication of dissolved element occurring from the parent rock. Such dissolution of minerals is an evidence of weathering with water as a dominant agent. The presence of water for the dissolution could be associated with rainfall and runoff activities. These variables can be identified as metals while the underlying factor is the earth surface processes and socio –economic activities of man which facilitated the break down and emission of elements in our river water.

Component 111: In this component, TDS (X12) (.702) and TSS (X13) (.855) had high loadings. These variables derived from particles transported by the river water which range from colloidal sizes of fragments to larger particles and in the process, the action of water on the sizes of the particles being transported leads to its dissolution. The underlying factor is therefore the influence of sedimentation on the river water of the drainage basin under study.

Component IV: The result of the PCA reveals that manganese (X1) (.755) and Dissolved oxygen (.858) had significant loading. These variables are indicators of dissolved mineral ion and aerobic breakdown of oxygen in the river water following microbial activities. On the whole, the underlying factor could be associated to organic –cum-earth surface processes.

Component V: This component has an eigen value of 1.917%, a variance of 10.650% and accumulative weight of 75.622%. In this component, calcium (X3) and turbidity (X18) (.740) are with significant loading. Most waters that are turbid are sediment laden. In the basin, loose soil structure and low stability index soils with sandy origin coupled with intense cultivation of farm land in order to increase food production, engendered the application of fertilizer. Chemical minerals from such activities find its way into the river and in addition to the hydro-geological structure and parent rock material of the river water environment, changes the water quality of the basin. Soil debris and sediment accumulate there by leading to turbidity of the river. The underlying factor is therefore the effect of soil erosion and socio –economic activities in the river water.

Component VI: The eigen value of this component is 1.767% with a variability of 9.817 and a cumulative of 85.44%. Only nitrate (X7) (.809) recorded a high weight. This variable is an indicator of contamination of river water by wastes with organic origin viz agricultural runoff, fertilizer, manure application, sewage disposal and other biological sources. Against the above background, the underlying factor is the influence of organic wastes in the river water.

HYPOTHESIS

The following hypothesis helped in arriving at a logical conclusion in this research.
Null hypothesis (Ho) There is no statistically significant difference between the water quality parameters in the rainy season and dry season.
Alternative hypothesis (H1) There is a statistically significant difference between the water quality parameters in the rainy season and dry season.
From the result of the analysis presented in Table 4a & b, with respect to the seasonality in the concentration level of the river basin, Turbidity (0.27), DO (.022), Temperature (0.11), Mn (0.17), Iron (.019), showed significant variation with regards to seasons. In this case, their p values were less than 0.05 while all other parameters had their p values more than 0.05. The paired sample correlation also confirms that some parameters showed a positive and strong significant variation in the two seasons. As a result, the alternative hypothesis was accepted. Thus, turbidity, sulphate, temperature, total suspended solids, iron, magnesium, calcium and carbon showed a significant, positive and strong correlation while other parameters did not show any significance and were weakly correlated. We therefore concluded that water quality of Mamu basin responds to season.

Degradation in the Basin Environment

Soil degradation is a serious environmental issue in that it affects the environment, agronomic productivity, food security, and quality of life. Soil degradation processes include the loss of topsoil by the action of water or wind, chemical deterioration such as nutrient depletion, physical degradation such as compaction, and biological deterioration of natural resources including the reduction of soil biodiversity (Eswaran et al, 2001; Lal, 2001; Birte et al, 2008).

In Mamu basin land degradation is evidenced by soil erosion occurring in large capacity of gully and small capacities of rill –cum-sheet. The intense rainfall in the basin and heavy dissection of the landscape by the river process facilitate such occurrence. This is further accentuated by the poor aggregate stability of the soil (table 5) and the soil textural class of the basin (table 6). From the result of the analysis (table 5), it was established that the study area has a low soil aggregate stability. This has accelerated the rate of detachability and erosion processes in the basin, thus leading to soil degradation.

From the particle size distribution and textural class of soil in Mamu basin (table 6), it is evident that Adada sub-basin, Oji sub-basin, Upstream of Mamu main channel and Ota-Alu sub-basins are made up of sandy soils. This explains why the soils particles in Mamu basin are easily eroded. Conversely, Ezu sub-basin and Obibia sub-basin soils are sandy loam and sandy clay loam, hence have high ability to resist detachment because of their retention of cations and adsorption of organic complexes (Carter, 1996) unlike sandy soils that have very low resistance to erosion.

From the foregoing, it can be deduced that the sandy fractions present in River Ezu and Obibia sub-basins are easily detached and transported into the basin. The rate of detachment of soil particles in the Ezu and Obibia sub-basins however will be lower than the Adada sub-basin, Oji sub- basin, Upstream Mamu main channel and Ota- Alu sub-basin because of their clay and loam fractions, which have higher water retention capacity than sandy soil. Thus, since the textural composition of the basin soil is mostly sand, which is coarse in nature, it shows that so long as the basin is dominated with sandy soil, its aggregate stability index will continue to be low. Hence, there is need to strengthen the stability of the basin soil with silt because increase in silt will increase structural index of the soil areas dominated by sand.

Conclusion

The Mamu basin is faced with varying forms of degradation largely forced by socio-economic activities of man. Most activities within the basin are primary economic activities especially farming, sand –cum- stone mining. Such activities have led to a gross modification of the landscape, decreased aggregate stability of soils, cases of afforestation and soil erosion within the basin. On the other, wastes generated from domestic and agricultural activities leave the basin in an unsightly condition. Generally, there is a variation in the water quality during the rainy and dry season which is traceable to activities going on within the basin. Thus, more eco-friendly practices should be promoted within the basin. Since man's economic activities are pivotal to the existing forms of environmental challenges in the river Mamu basin, it is imperative that appropriate regulation and management to combat such menace be enforced.

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