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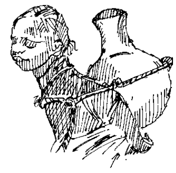
INTEGRATED DEVELOPMENT FOR WATER SUPPLY AND SANITATION



Nutrient status of two Ghanaian water reservoirs

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THE WEIJA AND Kpong Reservoirs were constructed as impoundments to satisfy the increasing demands for hydroelectric power and water for domestic, agricultural and industrial purposes. The Weija Reservoir, created in 1977 on the Densu River is about 116 km long. The Weija dam is a rock-and earth-filled structure located about 10 km from the mouth of the River Densu. The reservoir provided industrial and domestic water supplies to the southwestern part of Accra and for fisheries.

The Kpong reservoir created in 1981 was formed after the closure of the Volta Dam. It created the potential for two industries, agriculture by irrigation and fishing. The reservoir is also the main source of water supply to the Accra-Tema Metropolitan Area.

There is an urgent need to gather, analyse and collate nutrient data in order to mitigate adverse trends for maximum utilisation of these multipurpose reservoirs.

Study area

The Weija Reservoir has a surface area of about 300 ha and a depth of about 7m. The Reservoir lies at 5^0 35^1 N and 0^0 22^1 W. It has a mean annual inflow of 54.2 m^3 S^{-1}. Its catchment lies in the Coastal Savanna Zone where rainfall is seasonal with two peaks in June and September.

The outline of the Kpong Reservoir located at 6^0 9^1 N and O^0 5^1 E. The reservoir has a total surface area of 38 km^2 and a mean depth of 5m. It is characterised by small islands forming Senchi rapids in the north and the Kpong rapids in the south.

The mean annual flow of water through the reservoir is 1183 m^3/S and water retention time is 5 days. The main economic activities in the catchment of both reservoirs are fishing and crop farming.

Materials and methods

Water Samples were collected in clean 1 litre plastic bottles, pH and temperature were measured on the field using a portable pH meter and a mercury-in-glass thermometer respectively. Separate samples for dissolved oxygen (DO) determination were taken in plain glass bottles and the azide modification of the winkler method used.

For biochemical oxygen demand (BOD), samples were collected in dark glass bottles and incubated at 20^0C for 5 days after which the DO was determined.

All nutrients were analysed using colorimetric methods (APHA, 1985). The reservoirs were sampled six times yearly for 5 years. The months fell within the rainy season (April, May, June, July, September and October) and the dry season (November, December, January, February and March).

Results

Inputs by major settlements along the Weija and Kpong catchments are presented in Table 1. Inputs were calculated to determine their significance. The WHO rapid assessment for polluted waters (Suess 1982) was used for the computations. These were compared with main inflow rive loads.

The loads per capita per day were use to compute projected nutrient inputs from settlements to Weija Reservoir and Kpong Reservoir in 2010 (Table 2), based on population estimates supplied by Ghana's Statistical Service.

Seasonal indices for nutrients were calculated (Bajpai 1967) since some data do not indicate any trend or cyclical fluctuation as illustrated in Tables 3 and 4 for Weija and Kpong respectively.

Discussion

Physical parameters

In Table 5 is presented the mean temperature range for Weija, 29.3 - 31.0°C and for Kpong 28.9 - 30.8°C. Temperatures did not vary much over the 5-year period. The pH of both reservoirs was neutral due to their buffering capacity.

Chemical parameters

Dissolved oxygen (DO)

Oxygen is an important factor in the health of lakes. It is essential to the production and support of biological life in lake waters. In the Weija reservoir, the high DO concentrations indicate high phytoplankton populations. The 5-year monthly means ranged from 7.9 in November to 10.4 mg/l in March. The well oxygenated waters of the Weija reservoir may be explained by strong wind diffusion and photosynthesis. Moderate DO concentrations were also recorded at the Kpong reservoir. The monthly means for the 5-year period varied from 4.6 mg/l in January to 9.0 mg/l in September. In both reservoirs, the seasonal distribution was similar.

Biochemical oxygen demand (BOD)

In view of less agricultural activities around Kpong, BOD loads were quite low. The 5-year monthly mean concentrations varied between 2.20 in May to 4.22mg/l in March,

Table 1. Nutrient inputs form settlements

*Catchment Population (1997)**	*Settlement*	*Total N (Kg day^{-1})*	*Total P (Kg day^{-1})*	*Biochemical Oxygen Demand* (Kg day^{-1})
Weija				
3,919	Weija	47.0	11.8	235.1
1,109	Manhia	13.3	3.3	66.5
1,069	Afuaman	12.8	3.2	64.1
1,024	Domiabra	12.3	3.1	61.4
Kpong				
10,000	Kpong	120.0	30.0	600.0
2,868	Akrade	34.4	8.6	172.1
3,817	Akuse	45.8	11.5	229.0
3,547	Atimpoku	42.6	10.6	212.8

*1997 population estimates supplied by Statistical Service, Ghana.

Table 2. Estimated nutrient input from settlements in the Weija and Kpong catchments by 2010

*Catchment Population (2010)**	*Settlement*	*Total N (Kg day^{-1})*	*Total P (Kg day^{-1})*	*Biochemical Oxygen Demand* (Kg day^{-1})
Weija				
6,234	Weija	74.8	18.7	374.1
1,770	Manhia	21.2	5.3	106.2
1,706	Afuaman	20.5	5.1	102.4
1,634	Domiabra	19.6	4.9	98.1
Kpong				
13,450	Kpong	161.4	40.4	807.0
3,850	Akrade	46.3	11.6	231.5
5,134	Akuse	61.6	15.4	308.0
4,771	Atimpoku	57.3	14.3	286.3

*2010 population estimates supplied by Statistical Service, Ghana.

Table 3. Seasonal index of nitrate for Weija

Year / Period	*1993*	1994	*1995*	*1996*	*1997*	*Total*	5-Year *Average*	Seasonal *Index*
January	0.27	0.20	0.16	0.49	0.10	1.22	0.24	24
March	0.08	0.02	3.64	2.39	0.48	6.61	1.32	133
May	0.28	4.57	4.96	0.36	0.15	10.32	2.06	208
July	0.18	<0.01	0.07	0.06	-	0.31	0.08	8
September	0.10	1.10	3.45	<0.01	-	4.65	1.16	117
November	0.12	1.39	2.54	0.17	-	4.22	1.06	107
Total of monthly mean							5.92	-
Average of monthly mean							0.99	

slightly above the natural background concentration of 1-

Table 4. Seasonal index of Silicate for Kpong

Year / Period	*1993*	1994	*1995*	*1996*	*1997*	*Total*	5-Year *Average*	Seasonal *Index*
January	8.5	13.0	10.8	11.7	1.40	45.4	9.08	95
March	9.5	0.43	12.1	12.4	<0.01	34.4	6.88	72
May	11.0	9.5	8.4	13.3	<0.01	42.2	8.44	88
July	11.5	6.3	13.1	13.2	-	44.1	11.03	115
September	9.4	11.1	12.2	1.0	-	33.7	8.43	88
November	9.0	7.5	28.2	9.7	-	54.4	13.60	142
Total of monthly mean							54.4	-
Average of monthly mean							9.57	

Table 5. Means for major physical parameters for 5 years period (ranges)

Reservoir	*Flow (m^3/s)*	*Depth (m)*	*Area (ha)*	*pH*	Temperature (^0C)
Weija	1089.7	11.9 - 13.6	3361.5	7.3 - 7.7	29.3 - 31.0
Kpong	1183.0	8.5 - 9.6	380,000	6.7 - 7.0	28.9 - 30.8

3 mg/l for freshwater. However, Weija had high BOD concentrations. For the 5-year monthly means, the range was from 5.48 in July to 8.16 mg/l in March. Kpong recorded the highest yearly BOD concentration of 4.4 mg/l and lowest of 2.5 mg/l in 1995. On the contrary, Weija recorded the highest of 8.4 mg/l in 1994 and lowest of 5.1 mg/l in 1995. The high BOD levels in Weija may be due to sewage, runoff from the agricultural activities and the overland. The pattern in the BOD spatial distribution in the two reservoirs was similar.

Nitrogen

Ansa-Asare (1996) reported of increasing agricultural activities in the Weija catchment and high nitrate - nitrogen concentrations. Owning to this, algal blooms are common in the dry season. The weighted averages of the nitrate levels showed that Weija has high levels compared with Kpong. The difference is mainly due to the use of nitrate - based fertilizers in the catchment area. This is exacerbated by high BOD values which indicate the level of organic loading in the reservoir.

Seasonal variation showed higher nitrate concentrations in the rainy season at Weija than at Kpong. The monthly trend of nitrates showed a unique pattern in the months of March and May, the main ploughing periods for farming in the Weija catchment area when most fertilizer is applied.

On average, Weija showed higher concentration of nitrite than Kpong. Generally, there were higher nitrite concentration in the rainy season than in the dry season at Weija. However, for Kpong, there was not clear seasonal pattern.

For both Weija and Kpong, the distribution of ammonia showed a gradual increase over the five - year period and there was complete nitrification of ammonia to nitrate.

Orthophosphate

In relation to natural levels, orthophosphate levels were low. The lower concentrations of orthophosphate and ammonia - nitrogen had comparatively higher nitrate - nitrogen concentrations. Thus phytoplankton growth may be limited by orthophosphate, allowing nitrate to accumulate. This normally leads to algal blooms during the dry season. It is likely that phytoplankton growth in the Weija reservoir reduce the levels of orthophosphate (Biney, 1990). The generally low concentrations of orthophosphate and ammonia - nitrogen may also be explained that they were confined to bottom water as a result of the decomposition of organic matter in the sediments.

Silicate

In 1995, the highest silicate concentrations of 8.3 mg/l for Weija and 14.1 mg/l for Kpong were recorded. The seasonal silicate distribution for the two reservoirs was similar in pattern reaching peaks of 9.13 and 13.60 mg/l for Weija and Kpong respectively in November. Comparatively, the higher monthly means for Kpong reservoir may be because

Table 6. Seasonal indices for Weija

Month	Nitrate	Ammonia	Phosphate	Silicate	Sulphate
January	24	87	117	92	90
March	133	83	67	76	63
May	208	200	83	62	79
July	8	83	150	132	135
September	117	135	67	70	104
November	107	100	133	168	128

Table 7. Seasonal indices for Kpong

Month	Nitrate	Ammonia	Phosphate	Silicate	Sulphate
January	52	72	167	95	19
March	181	90	33	72	38
May	61	41	133	88	33
July	26	28	100	115	146
September	87	6.9	33	88	117
November	97	355	33	142	248

more silica organisms thrive there. Their exoskeletons descend from the upper layer to redissolve underneath or are deposited on the sediment layer which also redissolve into the water. Solubility of silica is increased by humic compounds and the formation of iron and aluminium - silicate - humic complexes.

Sulphate

For both reservoirs, the seasonal pattern of sulphate concentration did not vary much. Sulphate concentration increased gradually from March to July. This may be attributed to runoff after rains. The monthly means varied between 8.24 in March to 17.75 mg/l in July while those of Kpong ranged from 0.48 in January to 6.20 mg/1 in November.

Seasonal indices

In Tables 6 and 7 are presented the seasonal indices for Weija and Kpong. They indicate that high indices occurred in the rainy season and low ones in the dry season.

The phosphate index in January at both Weija and Kpong was however, high and the high nitrate index in March was due to rain in the latter part of the month. Ammonia - nitrogen in November also showed high indices because November is just after the rainy season so some effects of the rain persisted.

Conclusion

The estimated nutrient input for the year 2010 from settlements around Weija and Kpong reservoirs showed about 25.6 per cent increment. Over the 5-year period, the temperatures were constant with the pH well buffered. Nutrients spatial distribution in Weija showed high values compared with that of Kpong. Seasonal distribution of nutrients also showed high levels in Weija than Kpong. It was identified that land-based fertilizers and run-off were the main contributors to the nutrient loads.

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