SOME HIGHLIGHTS ON THE WATER QUALITY OF KAFUE RIVER

James M Kasonde

N C S R, Box 310158, Lusaka

ABSTRACT

A water quality study was conducted on the Kafue River on the copperbelt between 1987 and 1990. The aim was to find out the impact of various developmental activities on the river. The river is both a source of water for most of the urban population and a sink for waste-water emanating from various developmental activities. Results obtained indicate that the Kafue is polluted by effluents from the mines, sewage and industries.

NATIONAL COUNCIL FOR SCIENTIFIC RESEARCH

THE WATER QUALITY OF KAFUE RIVER ON THE COPPERBELT 1987 - 1990

INTRODUCTION

The Kafue river is important to the Zambian economy. Its river basin is a sub-catchment of the Zambezi river. In the upperpart of Kafue Basin is the Copperbelt, an area of about 48 Kilometres wide and 160 Kilometres long, bordering Zaire and stretching from elevation 1274 meters in the vicinity of latitude 13 South and Longitude 28 East (1, 2) fig. 1

CLIMATE AND VEGETATION

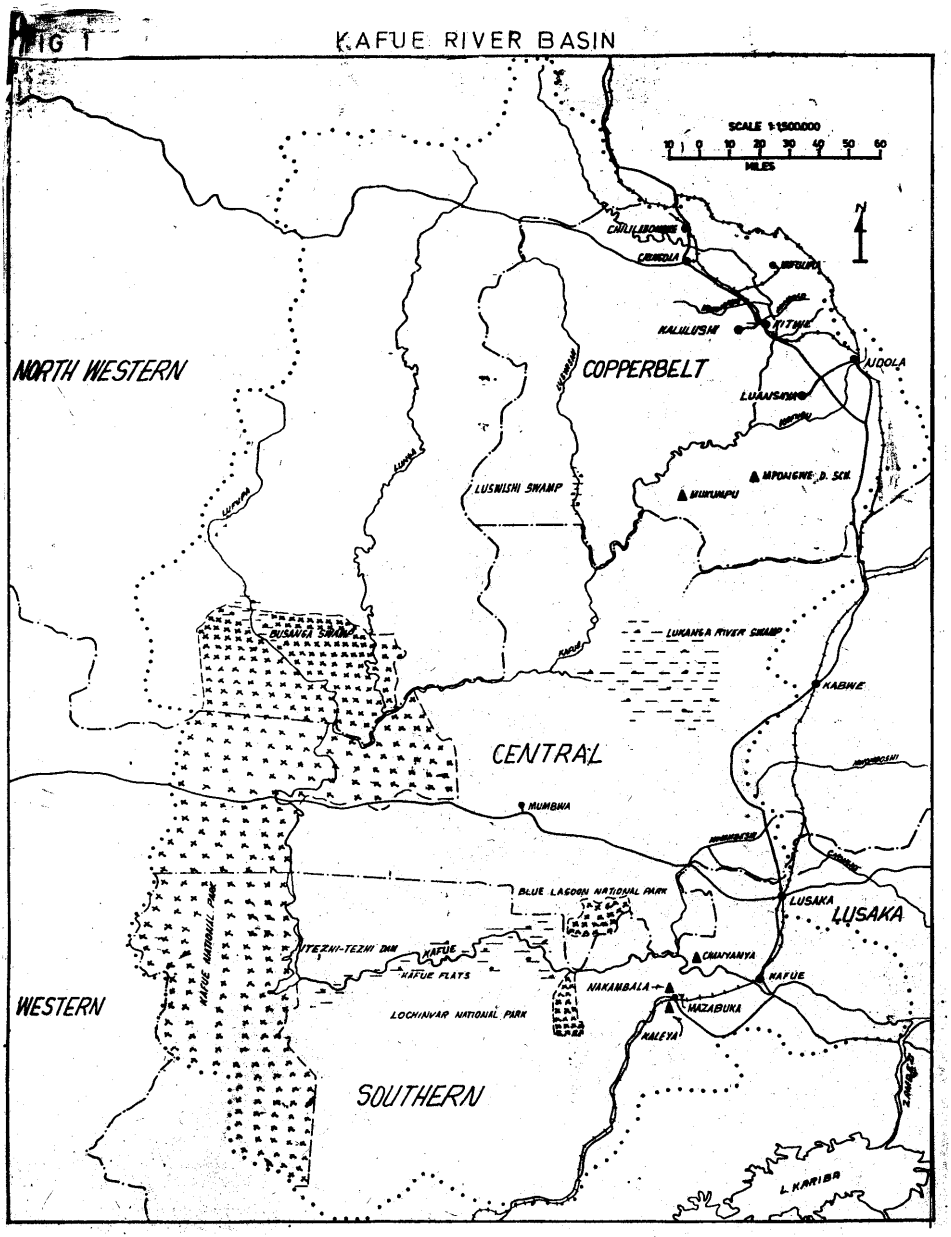
Although well within the tropics the climate of the copperbelt is tempered by the elevation. The year is divided into wet and dry seasons. The wet season lasts from Mid-November till the end of March. The rainfall is in the range 1250 millimetres. From the end of the rains to September the winter months prevail. The hottest months are September to November when mean temperatures reach 35°C.

The soils are leached and sandvelt. The vegetation consists of woodland dissected by streams and dambos. Riverine thickets are found along many perennial streams (1, 3).

DEVELOPMENT OF THE COPPERBELT

The Copperbelt is extensively mined. Approximately 26 million tonnes of ore are mined annually producing about 500,000 tonnes copper at six Mines. This activity has created tailing dams, paddock dams and scraper and rock dumps estimated to occupy 10,000 hectares of land. Associated with Mining is a large manufacturing industrial sector and large urban settlements. The estimated population of the copperbelt is, according to the 1990 Census, 1.579,542 (4)

FIG 1



THE HYDROLOGY OF KAFUE RIVER

The Kafue river has a mean flow of 80m/sec at Smiths Bridge. There has however been an observation decline in the flows as shown in fig 2. The minimum flows at Raglan farm are estimated at 0.84m/sec. These minimum flows on the copperbelt are augmented by addition of 3.74m/sec of ground-water from the mines (5).

MATERIALS AND METHODS

Water quality sampling to characterize the water quality of the Kafue river on the copperbelt was undertaken between 1987 and 1990. Sampling was limited to the period between March and September each year. The following parameters: pH, temperature, alkalinity and dissolved oxygen were analysed on site, while the other parameters were analysed from samples collected in 2 1/2 litter plastic containers and transported to the Environmental Research Laboratory of the National Council for Scientific Research in Lusaka. Standard methods (6) were employed to obtain the data from the sampling stations shown in fig 3.

RESULTS

The results of the water quality surveys undertaken on the copperbelt revealed that the Kafue river receives mine sewage and industrial effluents, which have affected the river water quality. The results are described parameter by parameter below, and are presented in table 1.

pH

The pH values of the Kafue river were found to be within guideline value of the 6.5 - 8.5, the range for most raw water sources.

Dissolved Solids

Dissolved solids content increase fourfold from a mean value of mc/1 at Raglans farm at points within the mining area on the Kafue river.

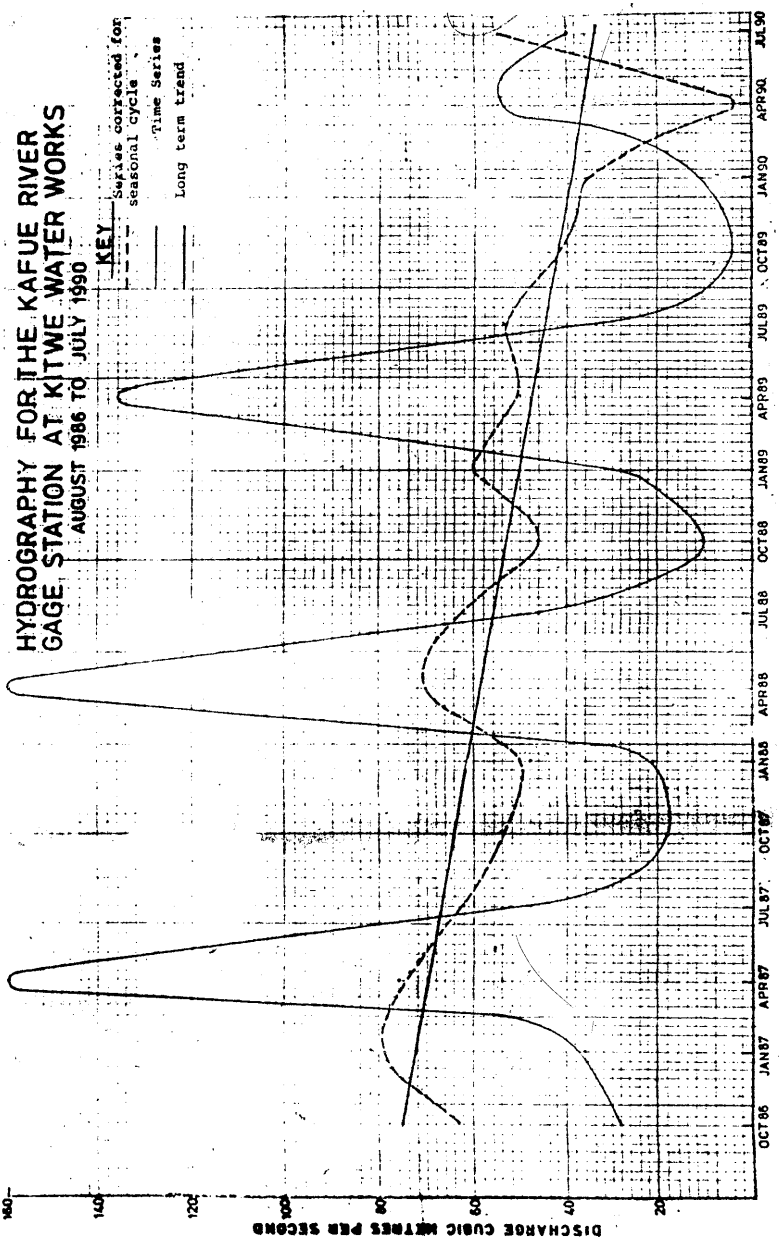
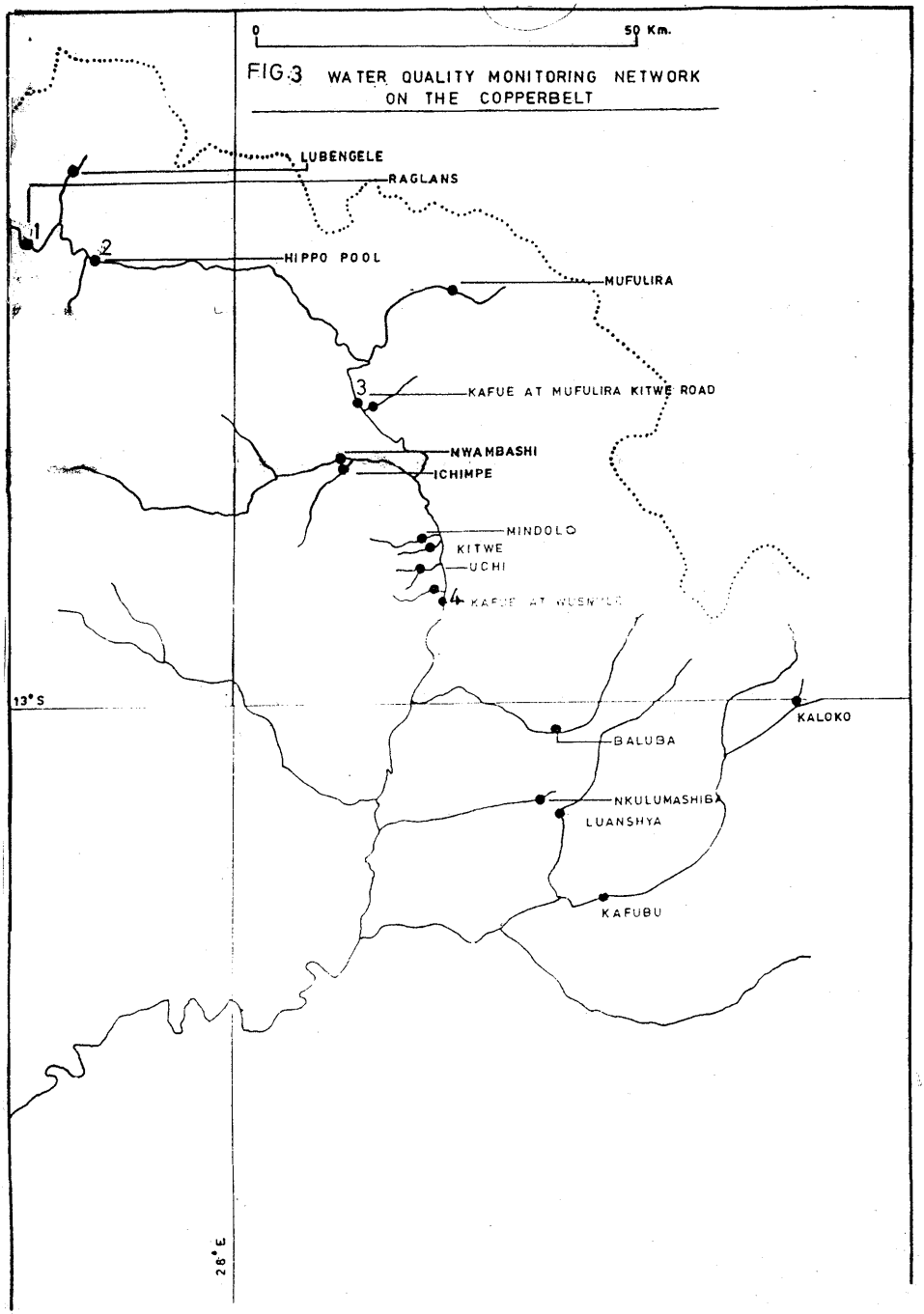


Fig 2

Source : ZCCM, Pollution control Dept., MITS.


0
50 Km.
FIG.3 WATER QUALITY MONITORING NETWORK ON THE COPPERBELT
LUBENGELE
RAGLANS
1
2
HIPPO POOL
MUFULIRA
3
KAFUE AT MUFULIRA KITWE ROAD
NWAMBASHI
ICHIMPE
MINDOLO
KITWE
UCHI
4
13°S
KALOKO
BALUBA
NKULUMASHIBA
LUANSHYA
KAFUBU
28°E

Suspended Solids

Suspended solids on the Kafue river at Raglans farm were very low, with a maximum of mc/1 Suspended solids. Very high amounts of suspended solids were recorded at Hippo pool as a result of suspended solids was measured.

Hardness and Alkalinity

The water quality of the Kafue river varies from soft to moderately hard. The contribution to hardness by non-carbonate hardness is substantial as hardness is almost twice alkalinity.

Sulphate

A substantial twelve fold increase in sulphate is observed on the Kafue rive immediately the Kafue river enters the mining area at Hippo-pool.

Chloride

Very low concentrations of chloride were observed on both the tributary streams and the Kafue river. The response to the input chloride can be however seen at Hippo-pool up to Wusakile bridge by an almost fourfold increase in chloride.

Phosphate - Phosphorus

The mean of Phosphates - phosphorous concentration on the Kafue river on the Copperbelt was around 0.5mg/1. There is a marked drop in phosphate at Hippo Pool and a rise in the maximum concentration at Wusakile bridge

Nitrates

Nitrates on the Kafue River and its tributaries were low. Nitrates however, are shown to increase six fold from the mean of 0.43mg/1 at raglans farm to 2.39 at Wusakile bridge.

Dissolved Oxygen

Low values of oxygen, mean 4.8mg/1, were measured Hippo-pool on Kafue river.

Sodium

Sodium values on the Kafue river were low increasing from 5.5mg/1 at Raglans farm to about 9mg/1 at Wusakile bridge.

Potassium

Potassium values are very low at Raglan farm. The mean value increases from 0.41mg/1 to about 8mg/1 when the Kafue river enters the mining area.

Calcium and Magnesium

Calcium and magnesium input into Kafue river can be seen in the increase of both metals in the Kafue river after it enters the mining area.

Trace metals

On the unpolluted part of the Kafue river at Raglans farm, only iron, copper and manganese were detectable at the following concentrations respectively, 0.22, 0.05 and 0.008mg/1.

Other trace metals cobalt, chromium, zinc and nickel were detected on the polluted part of Kafue river. The maximum concentrations for cobalt, chromium, lead, zinc and nickel, iron, copper and manganese were 0.32, 0.03, 0.38, 0.42 and 0.25mg/1 3.46, 1.53 and 1.12mg/1 in their maximum values respectively.

Discussion

From the data presented in table 1, it can be seen that the Kafue river is polluted upon entering the mining area. It is altered particularly with regards to suspended solids, hardness chloride.

The main source of suspended solids was identified to be mining at Hippo-pool, substantial input of suspended solids was found to be taking place. This has resulted in the silting up of the river below that point. Associated with the suspended solids were trace metals Lead, Arsenic, Cobalt, Chromium, Zinc, Nickel, Copper, Iron and Manganese. The bulk of the suspended solids was tailings. Suspended solids from run-off from dumps in the rainy season can be as much as 894mg/1. The discharge points in Chingola are within 7 Kilometres of the water intake (7, 8, 9).

The Mining Company standards for effluents are 6.5 - pH, 100mg/1 suspended solids, 1mg/1 dissolved copper and 0.5mg/1 dissolved cobalt (10). The water is rendered hard when it enters the mining area through non-carbonate hardness. This arises from calcium and magnesium sulphate from the mines (10). Ground water discharged to some local streams form the mines and discharges from tailings dams is hard. At Kalulushi at 7 shaft, the water is hard and has a high sulphate content of 575mg/1. At Mwambeshi 1426mg/1 sulphates have been recorded (11).

Even though the dissolved oxygen levels seen fairly good, observations made on local streams show that they receive substantial raw sewage and industrial effluents. These, like Kitwe stream showed extremely low values of dissolved oxygen. The large variation in the chloride concentration from a maximum of 1mg/1 at the control station to 48mg/1 and the increase in nitrates from a maximum of 0.68mg/1 to 5.12mg/1 at Wusakile bridge can be attributed to sewage.

Conclusion

The Kafue river on the Copperbelt is polluted. The main sources of pollution identified were mining sewage and industrial effluents. Impacts of mining and sewage were greatest at Chingola and Kitwe for respectively. The impacts are even more severe on local tributary steams.

Table 1: Water quality of Kafue river on the Copperbelt.

1a pH Units

Station No.	Mean	Max	Number of Observations
1	7.4	8.1	6
2	7.9	8.3	12
3	7.9	8.6	10
4	7.8	8.3	11

1b Dissolved Solids Mg/L

Station No.	Mean	Max	Number of Observations
1	105	359	10
2	244	537	13
3	294	519	12
4	334	576	13

1c Suspended Solids Mg/L

Station No.	Mean	Max	Number of Observations
1	1.8	6	8
2	59.4	262	12
3	8.7	34	11
4	11.1	46	11

1d Total Hardness Mg/L CaCo3

Station No.	Mean	Max	Number of Observations
1	53	126	7
2	221	356	13
3	242	318	11
4	255	388	1

1e Total Alkalinity Mg/L $CaCo_3$

Station No.	Mean	Max	Number of Observations
1	88	145	9
2	108	166	12
3	100	125	11
4	91	124	14

1f Sulphate Mg/L

Station No.	Mean	Max	Number of Observations
1	7	14	4
2	43	175	5
3	64	100	5
4	104	143	7

1g Chloride Mg/L

Station No.	Mean	Max	Number of Observations
1	11	13	7
2	18	48	12
3	15	43	10
4	17	48	12

1h Sulphate Mg/L

Station No.	Mean	Max	Number of Observations
1	0.5	1.77	7
2	trace 0.03	10	
3	0.04	1.40	7
4	0.5	3.31	7

1i Nitrate Mg/L

Station No.	Mean	Max	Number of Observations
1	0.43	0.68	9
2	0.30	0.64	11
3	0.56	2.00	11
4	2.39	6.12	13

1j Dissolved Oxygen Mg/L

Station No.	Mean	Max	Number of Observations
1	6.7	7.4	2
2	4.8	5.8	8
3	7.6	8.4	8
4	7.7	8.6	15

1k Potassium Mg/L

Station No.	Mean	Max	Number of Observations
1	0.41	1.4	9
2	4.4	8.3	12
3	7.8	12.5	12
4	6.4	14.5	14

1r Sodium Mg/L

Station No.	Mean	Max	Number of Observations
1	5.5	17.00	10
2	4.4	16.5	12
3	7.1	9.5	12
4	8.7	14.2	14

1m Calcium Mg/L

Station No.	Mean	Max	Number of Observations
1	13	15	2
2	19	34	5
3	33	63	7
4	35	75	6

1n Magnesium Mg/L

Station No.	Mean	Max	Number of Observations
1	9.5	14.0	4
2	13.2	22.5	8
3	12.1	24.3	7
4	15.8	27.0	8

1o Total trace metals Mg/L at Raglans farm

Parameter	Mean	Max	Number of Observations
Cu	0.05	0.14	
Mn	0.008	0.009	
Fe	0.22	0.34	

Cd, Co, CR, Pb, Zn and Ni were below 0.01

1p Total trace metals values Mg/L between Hippo-pool and Wusakile bridge

Parameter	Mean	Max	Number of Observations
Co	0.05	0.32	18
Cr	0.03	0.03	3
Cu	0.36	1.53	27
Mn	0.17	1.12	30
Fe	0.83	3.46	29
Pb below	0.01	0.38	21
Zn	0.06	0.42	22
Ni	0.03	0.25	13

Acknowledgements

This work was made possible through the funding obtained from the National Council for Scientific Research (NSCR) The support of the Secretary General (NCSR) and the entire staff of the water Resources Research Unit.

References

1. Mendsohn, F. The Geology of the Northern Rhodesian Copperbelt

2. Sharma, T C, Characteristics of the Run-off Processes in the Upper Kafue Basin, (NCSR/TR 51)

3. Meteorological Department, Lusaka, Climatological Summaries for Zambia

4. ZCCM 1984, Environmental Issues in the Copper Mining Industry

5. COMMANSAT IDEA PROJECT, NCSR Final Report, July 1991.

6. UPHA, Standard Methods for the Examination of Water and Waste-water, Thirteenth Edition

7. Sawula, G M, NCSR TR 58, Pollution in the Kafue River and Drinking Water Quality in the Chingola Township, July 1985

8. JICA, GRZ, Final Report on the Masterplan Study on the Major River Basins of Zambia, 1991

9. SADC Environmental Effects of Mining in the SADC region August 1992

10. J A Chairman, The Environment and the Kafue River, Proceedings of IEZ Seminar, the Engineer the Way Forward, Nov. 1990

11. ZCCM, Analytical Reports 1992