

**MINISTRY OF WATER, LANDS AND  
ENVIRONMENT**

*LAKE VICTORIA ENVIRONMENTAL MANAGEMENT  
PROJECT (LVEMP)*



FINAL REPORT ON WATER QUALITY SYNTHESIS FOR  
LVEMP I  
**December, 2005**

**Edited By**

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and  
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Dr. Fredrick J. Muyodi  
Prof. Robert E. Hecky.

## **List of Abbreviations, Acronyms and Symbols**

1. ADCP	Acoustic Doppler Current Profiler
2. AMSL	Above Mean Sea Level
3. AWSs	Automatic Weather Stations
4. BMUs	Beach Management Units
5. BOD	Biochemical Oxygen Demand
6. CIDA	Canadian International Development Agency
7. CIFA	Committee for the Inland Fisheries of Africa
8. COD	Chemical Oxygen Demand
9. COWI	COWI Consulting Engineers and Planners
10. CRM	Certified Reference Materials
11. DDT	DichloroDiphenylTrichloroethane
12. DFID	Department for International Development
13. EAC	East African Community
14. EAFFRO	East African Freshwater Fisheries Research Organization
15. ECD	Electron Capture Detector
16. ECOSAN	Ecological Sanitation Toilets
17. ENSO	El Nino Southern Oscillation
18. EPA	Environmental Protection Agency (USA)
19. FAO	Food and Agricultural Organization of the United Nations
20. FIRRI	Fisheries Resources Research Institute
21. GC	Gas Chromatography
22. GDP	Gross Domestic Product
23. GEF	Global Environment Facility
24. GPS	Global Positioning System
25. HPLC	High Performance Liquid Chromatography
26. IBIS	Research Vessel at FIRRI, Jinja
27. IDA	International Development Agency (World Bank)
28. IDRC	International Development Research Centre - Canada
29. IHE	Institute of Hydraulic Engineering (Delft)
30. IMB	Inner Murchison Bay
31. ISO	International Organisation for Standardisation
32. ITCZ	Inter Tropical Convergence Zone
33. IUCN	World Conservation Union
34. KCC	Kampala City Council
35. KL	Kenya Littoral Station
36. LVDP	Lake Victoria Development Programme
37. LVEMP	Lake Victoria Environment Management Project
38. LVFO	Lake Victoria Fisheries Organization
39. LVFRP	Lake Victoria Regional Fisheries Project
40. MoH	Ministry of Health (Uganda)
41. MSD	Mass Selective Detector
42. MSL	Mean Sea Level
43. NAM	Nedboer-Afstroemning Model

44. NWSC	National Water and Sewerage Corporation
45. OM	Organic matter
46. SIDA	Swedish International Development Cooperation Agency
47. SPSS	Statistical Package for the Social Sciences
48. STDs	Sexually Transmitted Diseases
49. TN	Total Nitrogen
50. TP	Total Phosphorus
51. TSS	Total Suspended Solids
52. UASB	Upflow Anaerobic Sludge Blanket
53. UBL	Uganda Breweries Limited
54. UBOS	Uganda Bureau of Statistics
55. UNDP	United Nations Development Programme
56. UNEP	United Nations Environmental Program
57. UP	Uganda Pelagic Station
58. UV	Ultra-Violet radiations
59. WEDC	Water Engineering Development Centre (United Kingdom)
60. WHO	World Health Organisation
61. WRMD	Water Resources Management Department

## **EXECUTIVE SUMMARY**

The Water Quality and Quantity Synthesis Consultancy is a consultancy contract between Lake Victoria Environment Management Project and the Consultant (Dr. Fredrick J Muyodi). The contract was signed on the 23<sup>rd</sup> June 2005 and is financed by a credit from the International Development Association towards the cost of the services to the Government of Uganda.

The overall objective of the consultancy was to provide professional advice and assistance to the Water Quality and Ecosystem Management Component (WQ Component) of LVEMP in Uganda and participate in the preparation of the regional Water Quality and Quantity Report over a period of 8 months.

The consultancy services provided involved networking and collaboration with key stakeholders including the Water Resources Management Department (Directorate of Water Development), Ministry of Water, Lands and Environment; National Water and Sewerage Corporation, Fisheries Resources Research Institute, Kawanda Agricultural Research Institute, relevant Project Component Coordinators, Subcomponent and Task Leaders. An International Consultant was involved in the overall guidance of the consultancy.

### **Terms of Reference**

One of the major tasks of the consultancy was to guide and help the national scientists in Uganda in the analysis, synthesis and interpretation of the data collected by the Water Quality and Ecosystems Management Component of LVEMP. The approaches used in achieving the objectives of the task included:

- conducting series of national working sessions and workshops under the guidance of the international consultant
- reviewing documents / records of data collected by the component during LVEMP 1 phase
- sourcing relevant data from other collaborators and stakeholders
- providing and reviewing relevant data from the international scientific literature
- data synthesis and development of trends, special and temporal variability and inter-parameter relationships on lake water quality and ecosystem changes
- the consultancy also involved liaising with scientist and consultants from the riparian states of Kenya and Tanzania in the preparation of the Regional Synthesis Report on Water Quality and Quantity of Lake Victoria where regional working sessions and workshops were conducted, under the guidance of the international consultant.

### **Major Outputs**

- Final synthesis national report on Lake Victoria
- Final Lake Victoria Environment Report
- Manuscripts for publications on current and long term trends in L. Victoria water quality and quantity at national level.

- Regional Synthesis Report on Lake Victoria (in conjunction with other consultants from the region).
- Manuscript for publications on current and long term trends in Lake Victoria water quality and quantity at a regional level.

### **Purpose of Synthesis Report on Water Quality and Quantity**

In order to achieve LVEMP objectives and Water Quality and Ecosystem Management objectives, in particular, a well-coordinated analysis, synthesis and interpretation of all relevant data was necessary. This formed the core purpose of the synthesis report on water quality and quantity.

### **Expected Usefulness of the Report**

One of the critical concerns of LVEMP is water quality and ecosystem management with the overall objectives of elucidating the nature and dynamics of the lake ecosystem by providing detailed information on the characteristics of the waters and the lake. Also, to improve management of industrial and municipal effluents and assess the contribution of urban run-off to lake pollution in order to design alleviation measures. In addition, LVEMP aims at establishing water quality monitoring network throughout the catchments and estimating the effects of resource exploitation.

The water quality and quantity synthesis report documents and explains the changes that have taken place over the recent decades, and provides an overview of the present water quality status as well as identifying past changes and continuing trends that may require remedial action. The report provides detailed information and spatial resolution at the regional scale to support environmental decision making in regard to possible remediation of undesirable changes that have reduced beneficial uses of Lake Victoria biological and water resources. It also identifies gaps in knowledge that will need to be addressed in the second phase of LVEMP.

### **Coverage of the Report**

Chapter one gives the background to the Lake Victoria Basin with regard to characteristics, uses, previous studies and development initiatives. Popular concerns, the objectives of the LVEMP water quality studies and recommendations for future action (including LVEMP 2) on the Uganda side are emphasized.

The number, selection criteria, frequency and descriptive statistics for pelagic, littoral and urban lake monitoring stations are presented in Chapter Two. The meteorology and hydrology studies and recommendations are presented in Chapter Three. Trends in temperature, rainfall, and wind are discussed. Annual rainfall by catchment and national totals, river discharge, lake estimates, evaporation and lake levels are covered.

Non-point source pollution loadings covering wet deposition, dry deposition as extrapolated from other areas of Lake Victoria, catchment loadings at river mouths and total loadings are presented in Chapter Four.

Chapter Five presents studies on industrial and municipal effluent loadings into the lake. Strategies to reduce effluents, clean technologies including tertiary treatment by wetlands, micro-project for community sanitation are reported. Urban and village lakeshore environments in terms of water uses and health risks are also presented.

The hydraulic conditions of Lake Victoria are presented in Chapter Six. Historic description of annual thermal cycles of pelagic waters, stratification cycle at pelagic stations in national waters, relationship to meteorological factors, oxygen vertical distributions in pelagic stations, depth dependence on stratification, stratification at littoral stations are discussed. Oxygen vertical distributions at littoral stations, temperature and oxygen conditions in shallow gulfs, interchange between gulfs and open lake and a general description of current velocities at different depths in the lake are presented.

Comparison with historic data for stations or areas where pre-LVEMP data exists is also discussed while numbers and frequency of pelagic and littoral stations, composition of sedimenting materials, areal flux rates, settling velocities and sedimentation rates of river deltas are presented in Chapter Seven.

Chapter eight and nine give detailed account of the studies on Lake Victoria eutrophication. Chlorophyll spatial patterns over time, chlorophyll-transparency relationship, chlorophyll-nutrient relationships, algal species distribution and nitrogen fixation (Chapter Eight); zooplankton and invertebrates diversity (Chapter Nine) are discussed. The appropriateness to use OECD indicative values for indicators of eutrophication to Lake Victoria is presented.

Studies carried out by LVEMP 1 on the levels of pesticides including agrochemicals and metals especially mercury is discussed in Chapter Ten. The relationship between water quality and health, potential health risks due to algal toxicity and water-vectored diseases in the riparian region of Uganda is presented in Chapter Eleven.

Chapter Twelve discusses the impacts of water quality change on beneficial uses of Lake Victoria. Drinking water impairment-treatment costs, water related diseases, food web contamination, loss of fish habitat, inefficient food webs, loss of biodiversity and nuisance macrophyte growth are presented in this chapter.

Chapter Thirteen describes capacity developed in terms of numbers / qualifications of trained staff, workshops conducted on water quality, laboratory capacities and field infrastructure, monitoring network and databases. Conceptual and theoretical models operationalized are also discussed. General recommendations for action in LVEMP II are finally presented in Chapter Fourteen.

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