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Addressing Land Based Activities in the Western Indian Ocean

GEF

INTERNATIONAL ATOMIC ENERGY AGENCY
MARINE ENVIRONMENTAL LABORATORY

REPORT TO UNEP AND WIO-LaB

An Assessment of the National Capabilities for Marine Pollution Monitoring in the Western Indian Ocean Region and Recommendations for Regional Capacity Building and Training Needs

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1 SCOPE

This report is based on two missions to the Western Indian Ocean region: i) South Africa, Mauritius, and Madagascar, July 24-August 7, 2005; ii) Mozambique, Tanzania, Comoros and Kenya, August 14-26, 2005. The Seychelles was not visited, but laboratory personnel provided information regarding capacity building requirements. The purpose of travel was to undertake a mission on behalf of UNEP and the GEF Project entitled *Addressing Land-based Activities in the Western Indian Ocean (WIO-LaB)* in order to assess national marine pollution monitoring and assessment capabilities, and thereby make recommendations for capacity building and training needs in the region. The report was finalised based on comments received at the second meeting of the *WIO-LaB Project Regional Working Group on Water and Sediment Quality Assessment and Monitoring* was held in Quatre Bornes, Mauritius, February 8-10, 2006.

2 BACKGROUND

The project entitled *Addressing Land-based Activities in the Western Indian Ocean (WIO-LaB)* is a UNEP-GEF project involving eight countries: Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, South Africa, and Tanzania. WIO-LaB is a four-year project that has a primary concentration on some of the major environmental problems and issues of the region associated with the degradation of the marine and coastal environment due to land-based activities. Some aspects of the implementation rely on establishing a regional monitoring programme.

The Marine Environmental Studies Laboratory of the International Atomic Energy Agency can provide technical support to underpin the regional monitoring programme. Such assistance includes conducting regional training courses for the analyses of metals and organic contaminants in marine sediments and biota, running regional inter-laboratory studies to judge laboratory performance, and provide expert advice on marine analytical chemistry, including QA/QC procedures. Also, MESL can assist the WIO-LaB Project in establishing a Regional Activity Centre for marine pollution monitoring. Other services can be offered once a regional monitoring programme is initiated.

3 NATIONAL ASSESSMENTS

Twenty-one laboratories and government agencies in seven countries were visited during two missions to the Western Indian Ocean region. The Seychelles was not visited. Discussions centred on the mandate of the laboratory to carry out marine pollution monitoring and the monitoring programme that they undertake, including parameters measured. The laboratories were toured to examine the general infrastructure and instruments, and to evaluate the QA/QC procedures in place. The following assessments are on a national basis in chronological order of country and laboratory / government authority visited.

3.1 South Africa

Council for Scientific and Industrial Research (CSIR)

The Council for Scientific and Industrial Research (CSIR) facility is located in Durban. Mr Ashley Naidoo (Business Area Manager for Coastal Processes) and Mr Roland David (Laboratory Manager) provided background information about CSIR in general and their marine pollution-monitoring programme, and gave a tour of the laboratory facilities.

South Africa has no national monitoring programme. The mandate for this activity rests officially with the Department of Environmental Affairs and Tourism (DEAT) through the Marine and Coastal Monitoring (MCM) branch. Because MCM has no operational capacity for chemical analyses, they rely on CSIR Durban to support marine pollution monitoring. CSIR also works directly with port and local authorities along the east coast of South Africa. The CSIR marine monitoring programme encompasses water, sediments and biota. Analytes in all media include heavy metals, chlorinated pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs) and total petroleum hydrocarbons (TPH). Additional measurements in water are the standard oceanographic parameters and nutrients. The laboratory also conducts bioassays (sea urchin toxicity test) and standard microbial assays for assessing water quality. CSIR has no vessel itself, but rather uses port authority vessels or charters a ship for offshore sample collection.

The CSIR facility has a suite of laboratories. The space is well-organised for sample handling and analyses, with designated areas for sample reception and storage, wet chemistry, and instrumental analysis. Summarising, there are two rooms for washing glassware, a storeroom with various fridges for sample storage, a room with various ovens and a muffle furnace, and a balance room. Apart from a large general laboratory, there are several dedicated laboratories: wet chemistry, determination of nutrients, sample preparation for analysis of sediments and biota (includes a microwave digestion system), and microbiology. Also, there are separate instrument rooms for the inductively coupled plasma - optical emission spectrometer (ICP-OES), atomic absorption spectrophotometer (AAS) used only for mercury, ion chromatograph, and gas chromatograph - mass spectrometer (GC-MS). Finally, there are various offices and a computer room with good Internet access. It should be noted that there is scope to expand the laboratory space. The glassware cleaning facilities will be centralised, the general laboratory is under-utilised and offices can be moved from the laboratory wing to the main building.

With respect to quality management considerations, competent authorities regularly calibrate balances and other equipment. Samples are tracked through chain of custody forms and using an in-house unique code number. Various certified reference materials are on hand, but none are available for the analysis of organic contaminants. Quality Control (QC) charts are kept to monitor analytical performance of the laboratory. CSIR participates regularly in external laboratory performance tests run by the South African Bureau of Standards. They used to take part in some QUASIMEME studies, and still periodically partake in Ultracheck tests for water quality analyses. They have not been involved in IAEA laboratory performance studies, but plan to participate in future studies. The laboratory is accredited by the South African Bureau of Standards for many analyses, including several metals in estuarine waters and sediment.

CSIR has a good system of documentation, which includes sample logs, instrument logs, calibration information, staff training logs, and standard operation procedures (SOPs). The staff training logs are of note because there is an in-house training scheme that teaches unqualified people to become analytical technicians. Finally, it was noted that for sub-contracting out work, they use only other accredited laboratories.

The WIO-LaB Project hopes to establish the CSIR Durban laboratory as the Regional Activity Centre (RAC) for Marine Pollution Monitoring. The facility has many strengths to support this proposal: ready accessibility from throughout the region, good communications support (fax, email, high speed internet access); relatively large laboratory space with possibilities for expansion; good facilities for hosting meetings and training courses; in-house training scheme and experience hosting interns from other countries; well-organised laboratory environment with good instrumentation; trained staff with experience in a wide range of sampling and measurement procedures; many good aspects of quality management and document keeping; and accreditation by the South African Bureau of Standards for many analyses. Moreover, CSIR is located on the campus of the University of Kwazulu-Natal and also has ready access to the nearby Durban Institute of Technology. However, there are also some deficiencies that need to the rectified: currently insufficient attention to the use of reference materials and certified reference materials, especially for analysis of organic contaminants; sporadic participation in external laboratory performance studies; some instruments are possibly too sophisticated for regional training (*i.e.* ICP-OES rather than AAS, and GC-MS rather than GC-FID/ECD); no equipment for the preparation of reference materials (freeze-dryer; grinder; homogeniser). Another point for consideration is that there should be a clearly defined devolution of the various tasks, such as running training courses, organising laboratory performance studies and subsequent statistical interpretation of data, to ensure that they do not all become the responsibility of the laboratory manager. Such consideration is a management issue reflecting the scale and diversity of the activities, rather than the qualities and abilities of any given laboratory manager.

Comments

The CSIR Laboratory in Durban could serve as a Regional Activity Centre for marine pollution monitoring for the WIO-LaB Project, but subject to the following recommendations:

- CSIR must improve analytical performance in the determination of organic contaminants in marine matrices; specifically they should acquire appropriate reference materials and participate in relevant laboratory performance studies.
- CSIR should have (or have ready local access) to appropriate instrumentation for hosting training courses, notably one or more better graphite furnace atomic absorption spectrophotometers and gas chromatograph(s) with flame ionisation detector (GC-FID) and electron capture detector (GC-ECD). Although one GC with both detectors would suffice, a better long-term strategy would be to have two GCs with different detectors.
- CSIR needs to be equipped with some equipment essential for the preparation of regional reference materials, namely freeze-dryer, grinder, sieves, and homogeniser.
- Appropriate staff to teach the training courses needs to be designated, as does the person that will become responsible for organising the laboratory performance studies, which includes statistical interpretation of the data.

- CSIR staff needs to be trained to undertake the anticipated tasks, many of which are beyond their present experience, but not competence.

3.2 Mauritius

In Mauritius, local hosts from the Ministry of the Environment were Ms Nashreem Soogun (WIO-LaB National Focal Point for Mauritius) and Ms Daisy Ramasamy. They provided some background information regarding the marine environment. As regards land-based sources of pollution to the marine environment, they indicated that discharges to the coastal lagoon are prohibited and that emissions to the ocean are permitted only via outfalls deeper than 30 m and at least 1 km offshore. Mauritius has an inter-ministerial committee, chaired by the Ministry for the Environment, dealing with all pollution issues.

3.2.1 Central Water Authority (CWA)

The Central Water Authority Laboratory is located in St Paul. Mr Anand Kumar Gopaul (Scientific Officer) and Mr S.K. Pem (Technical Officer) explained that the CWA operates under the auspices of the Ministry of Public Utilities and has the mandate to monitor surface waters, ground waters, industrial effluent discharges into surface waters and drinking water. Although they have many sampling locations, the sites of greatest relevance to WIO-LaB are sites situated at the mouths of rivers entering the sea. They measure standard water quality parameters, including nutrients, to ensure that waters comply with national standards as stipulated by the Ministry of the Environment. They consider that metals and pesticides are not a problem in surface waters, the later based on a previous study of the main pesticides used for growing sugar cane.

The CWA facility has a suite of laboratories. The space is limited, but relatively well-organised. There is an office that doubles as a storeroom for documents, a storage room for samples (but the fridge was not functioning), a wet laboratory, and a sample preparation laboratory equipped with a flame photometer. Another general purpose laboratory contained instruments for the determination of total organic carbon (TOC) and total organic halides (TOH), together with a centrifuge and muffle furnace. The nutrient laboratory had an apparatus for measuring total Kjeldhal nitrogen (TKN) and also two gas chromatographs (GCs), one with a nitrogen-phosphorus detector (GC-NPD) and the other with an electron capture detector (GC-ECD). However, the GCs were not operational. Finally, there was a separate laboratory housing an old and non-functional atomic absorption spectrophotometer (AAS).

Regarding quality management, the CWA laboratory has few QA/QC procedures in place. They do produce in-house reference materials for QC checks and maintain QC charts. However, they do not participate in external laboratory performance studies. They are in the process of preparing a quality manual and will seek accreditation by Mauritius Accreditation Services (MAURITAS), which operates under the auspices of the Ministry of Industry.

3.2.2 Waste Water Laboratory (WWL)

Mr Jacques Alexis Radhay (Works Manager for the Pollution Control Unit), Mr Shameem Jauffur (Scientific Officer), Mr Shailand K. Guunoo (Scientific Officer), and Ms Sunita Balgobin (Senior Laboratory Technician) provided information about the Waste Water Laboratory (WWL) in Réduit. The WWL also operates under the Ministry of Public Utilities and has the mandate for compliance monitoring of industrial emissions, mostly into the sewer system, but occasionally into surface waters and so overlaps with the mandate of the CWA. Of relevance to WIO-LaB is that they monitor the quality of water destined for discharge via the ocean outfalls, of which there are currently four in Mauritius. They routinely measure standard water quality parameters using the American Public Health Association (APHA) Standard Methods. They do not yet analyse metals, having just received an atomic absorption spectrophotometer (AAS). They undertake routine microbiological analyses.

The laboratory has very limited space. The balances are kept in an office together with various computers. There is a separate room housing a newly acquired gas chromatograph – mass spectrometer. However, everything else is essentially done in one large chemistry laboratory, which is used for all sample preparations and contains several fume cupboards and instruments. This laboratory is well-equipped and instruments include: a recently acquired AAS with both flame and graphite furnace capabilities, an oil and grease analyzer, a flame photometer, a microwave digestion system, a total Kjeldhal nitrogen analyzer, an UV/visible spectrophotometer, various small meters for pH, conductivity, ion selective electrode, *etc*, a flow injection autoanalyzer for nutrients and phenols, and a tintometer, together with various data loggers and field autosamplers. Finally, there is a small suite of rooms hosting the microbiological studies.

Regarding quality management, the WWL has few QA/QC procedures in place. They produce in-house reference materials for QC checks and maintain QC charts. They have no Certified Reference Materials and do not participate in external laboratory performance studies. They have good supporting documentation for sample collection and maintain a sample register. They do have clear reporting forms and in-house training of analysts.

3.2.3 National Environment Laboratory (NEL)

The National Environment Laboratory (NEL) is located in the same building as the WWL in Réduit. NEL is part of the Ministry of the Environment and has a mandate to investigate all environmental media (air, water, sludge), including the marine environment. Their role is more akin to troubleshooting rather than monitoring. They can measure a wide range of parameters. For water quality, NEL determines standard water quality parameters, including nutrients. Mr D. Dindyal gave a tour of the laboratory, which is divided into five sections: microbiology, wet chemistry, trace metal and air quality, liquid chromatography, and gas chromatography.

The microbiology laboratory is relatively spacious with well-organised workspace, albeit under renovation in order to comply with ISO standards. There are separate rooms for sample preparation, the preparation of media, a laboratory for laminar flow cabinets, and an incubator

room. They maintain reference strains of key microbes and run monthly swab tests to check for in-house contamination. They are preparing standard operating procedures.

The wet chemistry laboratory is very spacious and houses an UV/visible spectrophotometer. There is another laboratory dedicated to sample preparation for organic and metal analyses, with also contains a microwave digestion system and a total Kjeldhal nitrogen analyser. The liquid chromatography laboratory has a high performance liquid chromatograph (HPLC), an ion chromatograph dedicated to anion determinations in fresh waters, and a total organic carbon (TOC) analyser, together with Soxhlet extraction glassware. They measure benzene and a range of herbicides (diuron, velpar, linuron, and atrazine), and want to become ISO 17025 accredited. There is a gas chromatography laboratory that houses two gas chromatographs; one has a nitrogen-phosphorus detector (NPD) and a flame ionisation detector (FID), and the other one has an electron capture detector (ECD). However, the instruments do not function and the laboratory has no staff. Finally, the metal section has a flame photometer, and two atomic absorption spectrophotometers, one of which is equipped with a graphite furnace.

In terms of overall management, NEL is ISO 9001 2000 accredited. As regards chemical analyses, they are seeking accreditation by MAURITAS. They use the American Public Health Association (APHA) Standard Methods and have certified reference materials on hand. For internal QC, they use spiked solutions rather than a laboratory reference material. They do not currently participate in external laboratory performance studies.

3.2.4 Fisheries Research Centre (FRC)

After briefly meeting Mr Atmanun Venkatasami, the Director of the Albion Fisheries Research Centre, a tour of the facility was given by Mr Hang Bhudoge (Scientific Officer), Mrs Olga Venkatasami (Scientific Officer), and Mrs Veemala Chelumbrun (Technical Officer). The FRC runs a water quality monitoring programme, sampling seawater at the mouths of the main estuaries with a frequency of two to three months. They measure standard water quality parameters, including nitrate and phosphate. Bathing water quality is measured on a monthly basis.

The laboratory is rather limited. They have an atomic absorption spectrophotometer and a mercury analyser, but neither instrument is functional. They have an HPLC that is used for pesticide analyses. The microbiology laboratory is suitably equipped for the measurements made. Finally, it is noted that FRC has small boats suitable for sampling coastal sites.

In terms of quality management, they are considering getting accreditation by MAURITAS, but need an external expert to assist because there is no in-house expertise in chemistry. They have standard operating procedures and keep quality control charts, but do not participate in external laboratory performance tests.

Comments

Overall there is impressive capacity in Mauritius to undertake monitoring of many marine pollutants. However, there is currently no rigorous marine monitoring programme and all the

laboratories focus on water analyses, with virtually no attention paid to sediments and biota. The laboratories visited have overlapping capacities, and indeed, there seems to be some redundancy in their current monitoring programmes. The focus is on standard water quality parameters, including nutrients and microbial indicators. Some metal determinations are made, but there is no comprehensive assessment of organic contaminants. Generally, the laboratories need assistance to establish better QA/QC practices. Training in metal and organic analyses would be beneficial, especially for the Waste Water Laboratory, which has recently acquired sophisticated instrumentation, but has no relevant experience in their application. A coastal contaminant survey of metals and pesticides in sediments would provide valuable baseline information that seems to be lacking at this time. Finally, Mauritius would benefit from establishing a national monitoring programme to make use of the various experts and instrumentation that already exists in a more coordinated way.

3.3 Madagascar

3.3.1 Institut Halieutique et des Sciences Marines (IHSM)

In Toliara, the Institut Halieutique et des Sciences Marines (IHSM) is part of the University of Toliara. They operate under the auspices of the Ministry of National Education and Scientific Research, rather than the Ministry of the Environment. Mr Man Wai Rabenevanana (Director), Ms Jacqueline Razanoelisoa, (Fisheries Engineer) Mr Jean Yves Monera (Chemist), and Mr Christian Guy Ealijona (Vice President of the University) provided detailed information about the facility. IHSM is a teaching and research facility with many overseas collaborators. They work under contract with the Ministry of the Environment for some projects. IHSM has small boats suitable for sampling coastal locations.

IHSM has a project sponsored by the Norwegian Development Agency to monitor pollution in two bays in southern Madagascar, namely the Bay of Toliara in the southwest and the Bay of Fort-Dauphin in the southeast. The monitoring comprises microbiological and chemical components, but all chemical analyses are done at the Centre National de Recherches sur l'Environnement (CSRE) in Antananarivo. For the microbial assessments, the sampling frequency is twice per month. They measure a range of enteric bacteria and faecal coliforms, phytoplankton with a focus on toxic dinoflagellates, benthos and macroalgae (seaweeds). They are trying to examine the impact of toxic algae on zooplankton and pubic health. The complementary chemical study centres on the analysis of heavy metals in seawater. In the Bay of Toliara, they analyse industrial discharges four times per month. In the Bay of Fort-Dauphin, they analyse 16 samples collected from throughout the bay twice a month. No pesticides are currently measured.

The laboratory facilities are aimed serving the needs of teaching. The spacious microbiology laboratory has several incubators, water baths, a centrifuge and many microscopes. They teach class sizes of about 10 students. A second laboratory houses the microscope for counting phytoplankton. Also attached is a small chemistry laboratory, however, there is no equipment other than a rotary evaporator. As noted above, metal analyses are conducted at the CSRE in Antananarivo.

There was nothing to discuss as regards quality management for chemical analyses.

3.3.2 Centre National de Recherches sur l'Environnement (CSRE)

The Centre National de Recherches sur l'Environnement (CSRE) is in Antananarivo. Dr Pierre Ravelonandro (Director) and Mr Yves Jean Michel Mong (Chemist), together with Ms Chantal Andrianarivo (WIO-LaB National Focal Point for Madagascar), outlined marine environmental issues in Madagascar. As is the case for IHSM, CNRE operates under the auspices of the Ministry of National Education and Scientific Research. Although the Ministry for the Environment actually has the mandate to monitor the marine environment, one of the axes of activity for CNRE upon its establishment in 1988 was meant to be environmental monitoring. However, this activity that has never been implemented in a meaningful way and there is presently no national marine pollution monitoring programme in Madagascar. Moreover, there are disparate activities relating to international and regional conventions that could be better coordinated. Thus, it would be useful to bring together the people responsible for national implementation of the Nairobi Convention and the WIO-LaB GEF Project with those dealing with the POPs Convention.

CNRE is relatively well-equipped, having received external support over the years from the World Bank, UNIDO and the IAEA. The work focuses on the analyses of aqueous samples, including surface waters, industrial effluents and marine waters. They determine a wide range of standard water quality parameters, including nutrients. CNRE apparently has no experience analysing pollutants in marine sediment and biota samples. Generally the workspace is well-organised in that there are several instrument rooms, and sample preparations are handled in separate laboratories. However, the workspace for sample preparation for metal analyses is very cramped, and contains a muffle furnace and ovens, as well as fume cupboards. There is a water laboratory that is divided into two sections. One for preparatory work has a water filtration system and oven. The other, containing a laminar flow hood, is used for analytical measurements, such as titrations. An adjacent instrument laboratory houses a centrifuge, Fourier transform Infrared Spectrophotometer (FTIR), and UV/visible spectrophotometer. There is a chromatography laboratory with two gas chromatographs, both having flame ionisation and electron capture detectors. The laboratory also has three high performance liquid chromatographs (HPLC), one with a fluorescence detector and the other two having UV/visible detectors. The instruments are used to determine polycyclic aromatic hydrocarbons (PAHs), and although the laboratory has the equipment necessary for pesticide analyses, the staff lack experience in this field. A separate laboratory houses two atomic absorption spectrophotometers. The older instrument is just a flame AAS, whereas the newer AAS has flame, hydride generation and graphite furnace capabilities. Finally, there is a laboratory for the field equipment and staging field work. CNRE has a portable ion selective electrode system for measuring a range of metals *in situ* and a portable hydrocarbon analyser. This room also houses a freezer and the deionisation system.

CNRE relies on publications of the Association Française de Normalisation (AFNOR) for standard methodologies. The laboratory essentially operates without any QA/QC procedures at this stage. They have no certified reference materials, do not keep quality control charts and no longer participate in external laboratory performance studies.

Comments

There seems to be a lack of communications between ministries having the mandate to monitor marine pollution and the operational capacity to do so. They need to hold a national meeting (1 or 2 days) in Antananarivo to bring together the relevant administrators and scientists in order to clarify what marine studies should be done, what relevant research is/has been done and how to coordinate the resources and people in order to satisfy the national obligations stipulated in various international and regional conventions and projects. Although CNRE in Antananarivo is well-equipped for the determination of many marine pollutants, the staff needs assistance in a number of areas. Most importantly, CNRE must establish QA/QC procedures for all analyses. The staff needs training in the determination of pesticides, and for the analysis of pollutants in sediments and biota. Finally, IHSM in Toliara wants to expand its chemical studies. One suggestion is that they start by analysing nutrients in the Bay of Toliara. This would support the ongoing microbiological and phytoplankton studies, and could be justified in that the measurements should be made as soon as possible after sampling. Suitable training and some capacity building would be necessary. The equipment requirements would be an UV/visible spectrophotometer, glassware and chemicals.

3.4 Mozambique

3.4.1 National Laboratory of Food and Water Safety (NLFWS)

The National Laboratory of Food and Water Safety (NLFWS) is part of the Ministry of Health. Mr Carlos Domingos Sono is the Director and Ms Rhoda Nuvunga Luis serves as the Laboratory Manager. In terms of its monitoring role, the laboratory runs a water quality programme that focuses on drinking, surface and wastewaters. They determine standard water quality parameters, including several microbial measurements. They analyse marine waters infrequently. This laboratory has neither a mandate for environmental monitoring nor any enforcement role; however, the laboratory is a national facility and analyses samples from many clients, including the Ministry for the Environment and the Eduardo Mondlane University.

The NLFWS, quite spacious and well-organised, has a suite of offices and laboratories. There are rooms dedicated to sample reception, balances, and the production of distilled water, together with a dark room for reading thin later chromatography plates. Sample preparation areas are apart from instrument rooms. One sample preparation room contained several fume cupboards, which would be suitable for handling digestion and extraction procedures for marine sediments and biota. The chromatography laboratory has one high performance liquid chromatograph and two gas chromatographs; one with flame ionisation and electron capture detector and the other with thermal conductivity detector and electron capture detector. All three instruments are very old, and only one GC seems to be functioning, but with unknown stability and sensitivity. Another instrument room houses an UV/Visible Spectrophotometer and an old, inoperative Atomic Absorption Spectrophotometer. The laboratories for water quality studies (standard physicochemical measurements and nutrients) are equipped as required and very well-organised, with chemical reagents for specific analyses kept conveniently together on the workbenches. Bench top instruments include a turbiditimeter and a flame photometer.

With respect to quality management, the laboratory relies on the American Public Health Association (APHA) Standard Methods. They have sample log sheets, used for documenting sampling, analyses and results. NLFWS maintains a sample registry for tracking samples and progress of analyses. All instruments have a logbook, used to record usage and performance, the later forming a quasi quality control sheet for some instruments. They participate in an annual proficiency test for water quality run by the Southern African development community Cooperation in Measurement Traceability (SADCMET). They have demonstrated good quality, with an average z-score last year <1. This reflects the competence of the staff. There dedication is manifest in that they welcome students from both the Eduardo Mondlane University and high schools to undertake training in the laboratory.

3.4.2 Physics Department, Eduardo Mondlane University

Dr Antonio Huguane, a physical oceanographer at the Physics Department of Eduardo Mondlane University runs a small research group that started in the 1990s with an emphasis on applied oceanography aimed at fisheries management. Initially the investigations were offshore, but coastal studies have become increasingly important. The group has developed hydrodynamic models for Maputo Bay, mesocscale models for offshore studies, and is now looking at storm surge effects on coastal regions. Dr Huguane has been involved in several coastal projects, and co-supervises MSc and PhD students registered at other universities, but working in Maputo. They are now completing a LOICZ study of biogeochemical cycling in the Maputo Bay system, looking at several interfacial zones (open sea / Maputo Bay / estuaries / mangroves). Nutrient analyses for water samples were sub-contracted to the Department of Biology at the university and to the NLFWS. Other investigations include a World Wildlife Fund (WWF) sponsored study looking at an ecosystem approach to managing coastal shrimp fisheries, coastal zone management and development of marine protected areas funded by the EU, marine optics / water quality research to develop a camera system for measuring light penetration rather than a radiometer, and a tsunami early warning system based on tidal gauge data capture and transmission via satellite to have near real time information from remote sites. It is of note that the oceanographers use local fisherman when they need access to vessels for working at sea. Overall, the group represents users of marine data. They have no laboratory facilities for measurements and lack specific knowledge for interpreting chemical pollution data. However, they have expertise in hydrodynamics and have developed models of value for predicting pollutant transport within the coastal marine environment.

3.4.3 *Ministry of the Coordination of Environmental Affairs (MICOA)*

Mr Policarpo Napica is the Director of MICOA and the National WIO-LaB Focal Point for Mozambique. He confirmed that his ministry expected to play a coordinating role in the WIO-LaB project, noting that they would reply upon the services of the National Laboratory for Food and Water Safety for chemical measurements, and other ministries as required, For example the Ministry for Water has data on suspended sediment loads in rivers. He stated that they would convene, as required, an inter-ministerial meeting of the people involved in the WIO-LaB project in order to optimise coordination and minimise duplication of effort.

For my part, I voiced some of my observations. The MICOA had the mandate for environmental monitoring, but rely on the NLFWS for this service. This activity was outside the mandate of the Ministry of Health and the NLFWS currently lacked some instrumentation to implement the monitoring aspects of the WIO-LaB Project. Thus, it seemed that MICOA should bear some responsibility to securing adequate and appropriate instrumentation for NLFWS, either through national funding or leveraging external funds form donor countries or organisations. Finally, we agreed that Mozambique lacked expertise in the field of marine pollution assessment, that is, interpreting chemical data. Mr Napica indicated that MICOA could consider providing a scholarship to a student to undertake postgraduate studies in this field at a university outside Mozambique.

Comments

Mozambique has no national monitoring programme. The mandate for environmental monitoring rests with the Ministry of the Coordination of Environmental Affairs, but they have no operational capacity to make measurements. Thus, they must rely on the National Laboratory of Food and Water Safety. This laboratory is well-organised and maintained, but needs an atomic absorption spectrophotometer and a gas chromatograph with both flame ionisation detector and electron capture detector. MICOA should take the responsibility for securing the necessary funds for such instrumentation to ensure that Mozambique can participate fully in the monitoring aspects of the WIO-LaB Project. The laboratory also needs some training to upgrade QA/QC procedures and to gain familiarity with the analyses of metals and organic pollutants in marine sediments and biota. It is noted that there is expertise in coastal hydrodynamics at the Eduardo Mondlane University, but a national gap is expertise in marine pollution assessment. Given that there are some sporadic historical data of interest, Mozambique would benefit from having a data centre, or access to a regional data archiving faculty.

3.5 Tanzania

3.5.1 *University of Dar es Salaam*

At the Faculty of Aquatic Sciences and Technology (FAST) at the University of Dar es Salaam, Professor Yanus D. Mgaya is the Dean and Professor John E. Machiwa is the Head of Department of Aquatic Environment. As a university, the prime purposes are teaching and research. Thus, they do not have a marine monitoring programme *per se*, but have been involved in various case studies and research projects. Other departments on campus have suitable instrumentation for the analysis of metals and organic pollutants in marine sediments.

Ms Jean K. Mujumba runs the laboratory facilities in the Geology Department. The analytical facility for the analyses of metals comprises a suite of rooms. A range of environmental samples, including biological materials, is analysed. The facility is relatively spacious and, for the most part, well-organised. There is a balance room and a general laboratory area for staging fieldwork, sample reception and glassware cleaning. There are two sample preparation areas, complete with fume cupboards and a microwave digestion system, water production system and a total mercury analyser. However, the later item should be moved into one of the instrument rooms. There are two instrument rooms; one houses an inductively coupled plasma

optical emission spectrophotometer (ICP-OES) with autosampler and the other contains an atomic absorption spectrophotometer. Despite having a graphite furnace and autosampler, this old instrument only functions in the flame mode. Although the laboratory does have some reference materials, overall there is little laboratory management in effect. They do not participate in external laboratory performance studies and do not maintain quality control charts. Overall, record keeping is very limited; this applies to sample registry and instrument logs.

Professor Michael A. Kishimba and Mr. Geoffrey S. Malisa are members of the Chemistry Department. Of relevance to the WIO-LaB project, the department hosts two key laboratories for the analysis of organic contaminants. One laboratory is used for sample preparation, and has fume cupboards, centrifuge, ultrasonic water bath and rotary evaporator, together with the necessary glassware. They do not routinely use Soxhlet extraction because some pesticides that are measured suffer thermal degradation. The separate instrument room contains several apparatus, of note being two gas chromatographs (electron capture detector / flame ionisation detector; electron capture detector / nitrogen - phosphorus detector). One gas chromatograph was under repair, but both are functional. They note that they have good service from Varian, but tend to get spare parts via a colleague in Sweden rather than from South Africa. In terms of laboratory management and QA/QC procedures, the laboratory has many good practices in effect. Access to instruments is limited, and generally restricted to staff and postgraduate students under supervision. The laboratory is part of the African Network for Chemical Analyses of Pesticides (ANCAP) and has in place a system of split sample analyses for pesticides with colleagues in Kenya, Uganda and Sweden. The laboratory also forms part of the *Great Lakes Instrumentation Collaboratory*, led by Dr Alanah Fitch of the Loyola University Chicago, which is a web-based system for real time assistance with chemical analyses. They have various reference materials and participate in laboratory performance studies, notably the IAEA global intercomparison exercises. They maintain instrument logs and a sample registry. Overall, the credibility of results is manifest in the training of postgraduate students (6 MSc and 3 PhD) and the publication record in the peer-reviewed international literature. Finally, the Chemistry Department also has a laboratory containing two atomic absorption spectrophotometers, one of which has an autosampler and graphite furnace facility. No information was available regarding QA/QC practises. It should be noted that this instrument is more sensitive than ICP-OES and so might be of use for analyses of samples exhibiting metal concentrations below the detection limit of ICP-OES.

3.5.2 *National Environment Management Council (NEMC)*

Dr Ruzika N. Muheto is the Director of Environmental Planning and Research at the National Environment Management Council (NEMC). He indicated that NEMC would have a coordinating role for WIO-LaB in Tanzania. He noted that monitoring fell within the mandate of NEMC, but that this activity was contracted to the University of Dar es Salaam. Capacity building for monitoring was considered a priority. However, he felt that the sustainability of marine pollution monitoring after the lifetime of the WIO-LaB project would depend upon several factors, including outcomes from the project and the stability / retention of trained staff and project leadership.

3.5.3 *Institute of Marine Sciences (IMS)*

Dr Salim Mohammed is a staff member at the Institute of Marine Sciences (IMS) in Zanzibar. IMS is part of the University of Dar es Salaam. Working in a university setting, there is no monitoring programme, but marine investigations have comprised a series of short-term case studies concentrating on nutrients in seawater around Zanzibar and in the Port of Dar es Salaam. Many of these projects have received support form external donors (*i.e.* Sweden, Israel, and Canada) through the provision of equipment, training and collaborative research. IMS maintains close links with the main campus of the University of Dar es Salaam, notably running field programmes for students from the mainland and providing facilities for postgraduate students and staff.

Considering the chemical laboratories, IMS has very limited space at this time. However, a new facility has been planned and construction will start soon. Staff has had the opportunity to advise on laboratory needs and design. IMS has three chemical laboratories. The hydrolab is used for general chemistry, nutrient analyses, microbiological studies and sample preparation for metal analyses. It is equipped with a freeze-dryer and centrifuge, but fume cupboards have yet to be installed. Next door is the instrument room containing a new atomic absorption spectrophotometer equipped with flame, quartz furnace and graphite furnace capabilities. Other apparatus includes a CHN analyser, liquid scintillation counter, UV/visible spectrophotometer and balances. Finally, there is a pesticide laboratory, which is used only for sample preparation. Sample extracts are analysed at the Chemistry Department, University of Dar es Salaam.

IMS has a problem with instrument maintenance. My advice was that they request the assistance of experienced staff at the Chemistry Department, who seems to be adept at servicing instrumentation. As regards sample collection, they have a small boat suitable for inshore work. IMS has grab samplers, but the water samplers are old and not working properly. Surface water samples are collected by hand.

The laboratories at IMS have no set QA/QC procedures, with data quality being the responsibility of individual researchers and students. Thus, there are no samples logs, no sample registry, and no participation in laboratory performance studies. Whereas instrument user logs are recorded, there are no quality control charts to monitor analytical performance.

Comments

Although Tanzania has no national marine pollution-monitoring programme, both experienced staff and appropriate instrumentation to serve the needs of the anticipated WIO-LaB monitoring programme are available at the University of Dar es Salaam. The laboratory for pesticide residue analysis on the main campus has good QA/QC procedures in place, and produces credible data, as best manifested by the success of their postgraduate students and international publication record. As far as metal measurements are concerned, the laboratory needs to put into place better laboratory management, including QA/QC procedures. The same is true for nutrients analyses that are expected to be undertaken at the Institute of Marine Sciences. Metal analyses could also be undertaken at IMS.

3.6 Comoros

Dr Said Omar Said Hamidou (PNAC) and Dr Hamza Abdou Azali (INRAPE) acted as local hosts to various institutions and government departments in Comoros. The visit was catalytic in the sense that it was recognised that national network building would necessarily be the first step in participating in WIO-LaB. Different organisations in Comoros are coming together to scope out the Project and how best Comoros can rise to meet the challenges of marine pollution monitoring.

3.6.1 *Ministère du Développement Rural, de la Pêche, de l'Artisanat et de l'Environnement*

Brief discussions with Mr Hamadi Idaroussi, Secretary General, focussed on the WIO-LaB Project in broad terms and outlined the role of the IAEA Monaco Laboratory. Probably requirements in the Comoros were considered, together with possibilities for welcoming fellows in Monaco. The WIO-LaB Project should serve as a springboard to attract additional donor support, with France, Canada and Sweden as potential sources in the first instance.

3.6.2 *University of Comoros*

Hosts at the University of Comoros included Dr Damir Ben Ali, the President of the university, and Dr Kamaliddine Afraitaine, Dean of the Faculty of Science and Technology. As above, discussions were of an informative nature. Founded in 2003, the university has local staff that has been educated throughout the world. As a result, they have several partnerships with external universities and organisations, including the University of Perpignan, France, for a programme in food quality / safety. Of interest was the possibility of having graduate students undertake training at the IAEA Monaco Laboratory. The International Development Agencies of Canada (CIDA) and Sweden (SIDA) might fund scholarships in this vein, particularly if clearly linked to a high visibility project such as WIO-LaB.

3.6.3 *Pharmacie Nationale Autonome des Comores (PNAC)*

Dr Tadjiri Ahamada is the Director General of the Pharmacie Nationale Autonome des Comores (PNAC). The prime purpose of the laboratory complex is the production and analysis of various medications. Thus, they do not yet have a marine monitoring role and only some of the facilities are of relevance to the WIO-LaB Project. There is a small physicochemical laboratory, equipped with a colorimeter, flame photometer, high performance liquid chromatograph (not functioning during visit due to software problems) and a balance. There is a microbiological laboratory, having various items of field equipment, together with conductivity and pH meters. They analyse a range of waters, including marine, on a demand basis.

3.6.4 *Groupement d'Intérêts Economiques (GIE)*

The GIE is a small laboratory focusing on the quality of durable products, notably spices of economic importance due to export. The general laboratory has ample bench space, and contains a rotavaporator, polarimeter and Soxhlet extraction glassware. An instrument room

houses an UV/visible spectrophotometer and a gas chromatograph with a flame ionisation detector (GC-FID). The later was not functioning because gas generators for hydrogen and nitrogen were not operative, and using gas cylinders is prohibitively expensive.

3.6.5 *Institut National pour la Recherche d'Agriculture, de la Pêche et de l'Environnement (INRAPE)*

The laboratory at INRAPE is used only intermittently, and consists of a single room. Work centres on bioresources, and waters are not currently analysed. Regarding equipment, they have a good UV/visible spectrophotometer, balance, refrigerator and a fume cupboard.

3.6.6 *Direction Nationale de l'Environnement*

A final wrap-up session was held with Ms Ali Abdullah Fatouma, the Head of Department. Regarding potential pollution threats, the island is relatively sparsely populate and so has relatively limited inputs to the ocean. There is no major industry and only artisanal agriculture. The port is likely to be the most important hot spot on Grand Comoros. Otherwise, the main pollution seems to be due to waste and litter problems along the beach – visible pollution. I suggested that the ministry should organise a beach clean-up programme, starting with a pilot study in Mitsamiouli through mobilizing local school children in the first instance. I noted that Dr Ellik Adler, Coordinator of the Regional Seas Programme in UNEP had an interest in this area and could be contacted for additional advice.

Comments

There is no national marine pollution monitoring programme, and no current experience in the measurement of key pollutants of interest to WIO-LaB, other than the expertise for microbiological analyses at PNAC. However, there are well-trained and capable analysts, and some of the equipment required to undertake some determinations. PNAC and INRAPE plan to work jointly to establish a viable nutrient in seawater programme. This should be feasible, noting that IRAPE has a good working UV/visible spectrophotometer. Someone will need training at a regional laboratory that routinely makes such measurements. As regards the analysis of organic pollutants, GIE could serve as the national centre for such analyses. They have a gas chromatograph, but need their gas generators to be serviced and an electron capture detector to be added, provided the current instrument is not too old to be upgraded. Similarly, a person needs to be trained in analytical techniques and setting up appropriate QA/QC protocols. There is none of the instrumentation and equipment necessary for undertaking metal analyses. This should be a regional responsibility in the short to medium term, and ultimately will depend on the success of Comoros attracting external donors (*i.e.* France, Canada, or Sweden) perhaps using the high visibility of the WIO-LaB Project in formulating appropriate proposals. Finally, a beach clean-up campaign was suggested.

3.7 Kenya

3.7.1 *Kenya Marine and Fisheries Research Institute (KMFRI)*

Discussions at the Kenya Marine and Fisheries Research Institute in Mombassa were predominantly with research scientists Dr Daniel Munga and Dr Joseph Kamau, but I also made a courtesy visit to Dr Johnson Kazungu, Director. KMFRFI has the mandate in Kenya for marine monitoring, but there is no national monitoring programme. They have been involved in a number of case studies and undertaken project-driven targeted monitoring, usually aimed at integrated coastal management. The geographic focus tends to be Mombassa and the southern coast, but some studies have been conducted elsewhere in the Kenyan coastal zone. They mostly study waters (surface, ground and marine) and sediments, but have also examined marine biota with a view to verifying seafood quality for consumption. Standard water quality parameters, microbiological assays and nutrients are measured in water samples. Some past studies have included chlorophyll *a*. For sediments and biota, the main interest has been metals and little work has been done regarding organic contaminants. Extractable nutrients are also measured on occasion.

External donors, including EU, Belgium, the Netherlands and Sweden, have funded many of the projects. Apart from chemical monitoring studies, research topics have included sediment dynamics, harmful algal blooms, the fate of wastes discharged to sea from fish processing plants, coral reef conservation, leaching of metals from solid waste dumpsites and subsequent water-sediment exchange processes, and the ability of mangroves to filter and treat naturally domestic sewage.

The laboratories at KMFRI are relatively small, but current difficulties with restricted space should improve when some new rooms under construction are completed later this year. The nutrient laboratory has a dual channel autoanalyzer, which is currently not working due to a problem with the autosampler. Thus, measurements are currently made manually using an UV/visible spectrophotometer. Other apparatus includes balances and centrifuges. The microbiological laboratory is particularly cramped, but has everything necessary for measuring routine indicator organisms: laminar flow cabinet, fume cupboard, oven, water bath, autoclave, and refrigerator, all of which were in operating condition. Studies focus on waters (ground waters, beaches, and runoff), but sometimes include an assessment of seafood quality. The instrument room houses an old flame atomic absorption spectrophotometer, which no longer works, and two gas chromatographs equipped with flame ionisation detectors. One also has an electron capture detector that is not functioning. There is a general laboratory for chemistry and physics. This is used for sample handling and preparation. Equipment includes a set of sieves, Soxhlet extraction glassware, and the water distillation system. A biology laboratory houses another UV/visible spectrophotometer, together with a microbalance and some microscopes. KMFRI gets good IT support through the provision of GIS expertise and maintenance of an extensive bibliographic database. Finally, KMFRI has small boats for inshore work and access to larger vessels belonging to the Kenyan Wildlife Service for coastal studies. They have Niskin water samplers, a sediment grab and a corer.

With respect to quality management of the laboratory, no consistent procedures have been adopted. Record keeping has been the individual responsibility of project managers, and has

varied from project to project. Thus, there are no sample log sheets, sample register, or instrument logs. The laboratories have some reference materials from the IAEA and NIST, but do not maintain quality control charts. Also, they do not participate in external laboratory performance studies.

3.7.2 *Kenyatta University*

In the company of Ms Salome Machua (Senior Research Coordinator, Coastal Marine and Freshwater Department, National Environmental Management Authority), I visited Kenyatta University. Dr Godfrey Olukoye and Dr Stephen Anyango, two lecturers from the Department of Environmental Science, described the university's marine programme and projects. Kenyatta University now offers an MSc degree in the Environmental Science, in which pollution control and industrial safety are important components. Marine ecology is taught at undergraduate and postgraduate levels. As a university, no monitoring of chemical pollutants in the marine environment has been undertaken. Research projects in marine ecosystems have featured studies of heavy metals, but no work on organic contaminants has been done. Given the limited availability of instrumentation, especially in the Department of Environmental Sciences, samples are analysed making use of other facilities on campus, elsewhere in Nairobi and other locations in Kenya. Thus, they consider that the strength of the university and potential value to WIO-LaB is its human resources, notably academic leadership in marine ecosystem studies.

The facilities in the Chemistry Department comprise a set of five laboratories. There is a very large general laboratory for inorganic analyses, used for sample preparation for metal analyses. There are old fume cupboards and two Kjeldhal Nitrogen Analysers. Similarly, there is a spacious natural products laboratory, used for organic chemistry and sample preparation for chromatographic analyses. There is a smaller preparation laboratory housing balances and centrifuges. There are two instrument rooms. One contains a flame atomic absorption spectrophotometer and two flame photometers. The other is overflowing with various old pieces of equipment, notably gas chromatographs of which several are not operational. Of note, there is one gas chromatograph with both flame ionisation and electron capture detectors (FID, ECD). There are two ancient gas chromatographs, apparently still functioning, that have either an IFD or an ECD. Among other items is an infrared spectrophotometer, a CHN analyser (not working) and a polarograph. Given the overall state of the laboratories and the apparently poor housekeeping practises, especially in the organic instrument room, it is difficult to believe that reliable results for trace analyses of organic pollutants in marine samples could be obtained under such conditions.

The laboratories in the Department of Environmental Sciences are for undergraduate teaching. These new facilities are very spacious with new fume cupboards, but contain little in the way of sophisticated instrumentation. A preparation room has an oven, refrigerator and some field equipment. An attached storeroom houses a number of other pieces of field equipment (*i.e.* turbiditimeters, conductivity meters, dissolved oxygen probes, and pH meters), together with several balances, microscopes, water baths and centrifuges.

The laboratories at Kenyatta University have no quality management procedures in place. The facilities are predominantly for undergraduate teaching. Individual researchers keep their own

sample logs and sample registry. There are no instrument logs. The laboratories have no reference materials and do not participate in external laboratory performance studies.

Comments

Kenya has no national monitoring programme and it is not clear how internal resources will be used to implement the WIO-LaB Project. The National Environmental Management Authority has the coordinating role for the WIO-LaB Project in Kenya and apparently the Kenya Marine and Fisheries Research Institute in Mombassa will be the lead organisation for monitoring. KFMRI have the prerequisite experience and sampling facilities for undertaking the water quality monitoring, including microbiological and nutrient analyses. For organic contaminants in sediments, the gas chromatographic facilities in KMFRI are suitable for petroleum hydrocarbon analyses, but would need to be upgraded in order to be able to measure organochlorinated pesticides and PCBs. Neither KFMRI nor Kenyatta University has a graphite furnace atomic absorption spectrophotometer, as required for measuring metals in marine sediments. However, such an instrument is available at other institutions in Kenya that were not visited.

4 CONCLUSIONS

1. None of the countries visited in the Western Indian Ocean region has a comprehensive national monitoring programme. Chemical measurements in the marine environment have tended to be project-driven. Most such campaigns have focussed on water quality through determinations of standard physicochemical parameters, nutrients and microbiological indicator organisms. With the exception of nutrients analyses in Comoros, all countries have experience monitoring these parameters. Comoros does have the necessary instrumentation for nutrient analyses.

2. Regarding organic contaminant analyses, suitable instrumentation is available in South Africa, Mauritius, Madagascar, and Tanzania to determine petroleum hydrocarbons and organochlorinated compounds in marine sediments. In both Comoros and Kenya, there are operating gas chromatographs with flame ionisation detectors suitable for measuring petroleum hydrocarbons. Depending on the age of these instruments, it may be possible to upgrade them by adding an electron capture detector, thereby enabling the analysis of organochlorinated compounds. Mozambique has no functioning gas chromatograph. With respect to metal determinations, suitable instrumentation exists in South Africa, Mauritius, Madagascar, and Tanzania. However, Mozambique, Comoros and Kenya do not have a graphite furnace atomic absorption spectrophotometer, at least in the laboratories visited.

3. Regarding sampling, all countries have or have access to small boats suitable for coastal studies. Water bottles are available in all countries except Comoros, although in some cases they may need to be refurbished. There is much less experience in the region with handling sediment samples as compared to waters. Sediment grabs are available in Kenya, South Africa and Tanzania, but seemingly

not in Comoros, Madagascar, Mauritius, and Mozambique. Full participation in the pollution monitoring will require ready access to a grab, procured through the WIO-LaB project if necessary. Whereas a Shipek grab would be the preferred choice, cost considerations are likely to favour the procurement of Van Veen grabs.

4. The laboratories in the region have incomplete or non-existent quality management practices in effect. Establishing appropriate and uniform quality assurance / quality control procedures in the region is a priority. QA / QC must be emphasised in all training courses. With respect to nutrient analyses, someone from Comoros must be trained.

5. Maintenance of instruments is a problem in the region. There are limited service personnel, with the result that visits for diagnostics and repair tends to be costly. However, the efficacy of staff in the Chemistry Department of the University of Dar es Salaam in servicing their own instruments, notably gas chromatographs, was noticed. Perhaps the WIO-Lab project could use these staff to help service, maintain and upgrade instruments in the region.

6. Some of the countries seem to expect to rely on using universities and university students to run monitoring programmes. This is ill advised if students exclusively are to be used to make the measurements. While acknowledging that there is value in augmenting human resources in this way, there are long-term doubts about the sustainability of a monitoring programme. Moreover, if there is a marked turnover of staff or students, then additional problems may arise regarding leadership, training, knowledge management and harmonisation of data quality over the period of the project.

7. The sustainability of the marine pollution monitoring programme after the lifetime of the WIO-LaB project is in doubt. Most present and recent marine studies have been short-term projects or case studies funded, either completely or in large part, by external donors. Generally measurement campaigns have ended when the external funding ceased.

   Table 1 provides an overview of the capacity building (*i.e.* physical resources) needs in the countries participating in the WIO-LaB Project. The prohibitive cost of a graphite furnace atomic absorption spectrophotometer precludes the possibility of such equipment being procured through the WIO-LaB Project.

Table 1 Overview of capacity building needs

Country	GC[1]	GFAAS[2]	Sediment Grab	Water Sampler
Comoros	ECD[3] upgrade	Required	Required	Required
Kenya	ECD upgrade		Required	
Madagascar			Required	
Mauritius			Required	
Mozambique	Required	Required	Required	
Seychelles		Autosampler required	Required	Required
South Africa				
Tanzania				Refurbishment

1. GC = gas chromatograph
2. GFAAS = graphite furnace atomic absorption spectrophotometer
3. ECD = electron capture detector

5 RECOMMENDATIONS

1. All countries need to establish a national marine pollution-monitoring programme.

2. The region should undertake a coastal contaminant survey to establish the priority pollutants, potential pollution hot spots, and the major land-based sources of pollution.

3. All laboratories in the region that will contribute data to the WIO-LaB Project must establish credible quality assurance / quality control (QA/QC) procedures to guarantee a reliable and harmonised regional marine pollution monitoring programme.

4. Given that most laboratories have thus far dealt largely or exclusively with water samples, analysts need training in the collection and chemical analysis of marine sediments and biota.

5. Separate regional training courses should be given for the analysis of metals and pesticides in marine sediments and biota. A regional training course for the determination for nutrients in seawater would be beneficial, but at the very least, an analyst from Comoros must be trained in nutrient determinations.

6. Laboratories should participate regularly in regional proficiency tests and global inter-laboratory studies, such as those organised by the IAEA, for metals and organic contaminants. Participation in similar national studies should be continued and / or initiated where they exist.

7. A regional reference laboratory could be established at CSIR in Durban, but staff would need training in a number of areas before becoming operational.

8. All countries should receive some financial support in order to be able to carry out the water and sediment collection, and the determination of nutrients and organic contaminants. Thus, all countries should have samplers for water and sediment collection, together with a gas chromatograph equipped with a flame ionisation detector and an electron capture detector.

9. Where necessary, national authorities should take responsibility for procuring suitable instrumentation for metal analyses in order to participate fully in the anticipated marine pollution monitoring programme. In the short term, pollutant analyses should be undertaken at CSIR Durban for countries that do not have adequate analytical facilities.

10. An expert in the region should be identified that could help service and repair instruments.

11. National authorities should establish funding mechanisms to ensure that the marine pollution monitoring programme can be sustained after the lifetime of the WIO-LaB project.

6 ROLE OF IAEA-MESL

The Marine Environmental Studies Laboratory can assist in implementing the WIO-LaB Project in a number of ways as regards establishing a viable regional network of marine pollution monitoring laboratories:

1. Help laboratories establish QA /QC procedures

2. Organise regional proficiency tests for the analyses of metals and organic pollutants in marine sediments and biota

3. Encourage the participation of national laboratories in annual IAEA global inter-laboratory studies

4. Provide some marine reference materials and standards to laboratories

5. Run training courses for the analysis of metals and pesticides in marine sediments and biota, including sampling techniques

6. Establish communications with national laboratories in order to troubleshoot and provide expert advice on problems relating to marine analytical chemistry

7. Help set up a Regional Activity Centre for Marine Pollution Monitoring

8. Facilitate interactions between the IAEA Technical Cooperation Department and the various laboratories in IAEA Member States, via national Focal Points, in order to promote collaboration between IAEA-MEL and those laboratories.

Once the regional monitoring programme commences, IAEA-MESL could provide additional support to underpin the monitoring and assessment. Possible assistance encompasses quality assurance checks through split sample analyses, the determination of more demanding pollutants (*i.e.* organotin compounds), and expert advice for data interpretation and pollution assessment.