South Pacific Regional Environmental Programme Marine Coastal Pollution Study (SPREP-POL)

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Abstract

The South Pacific Region represents a substantial area of the world's major ocean. In response to concerns expressed by South Pacific Governments over the state of the marine environment, a proposal to undertake a marine coastal pollution study was initiated in 1989. As a part of the Regional Seas programme of UNEP, the project will attempt to assess the extent of pollution and quality trends by a series of monitoring and research activities at "clean" reference and known polluted areas. Areas to investigate include; ocean processes and properties, heavy metals, sewage and nutrients, pesticides and hydrocarbons. The paper will review previous work undertaken in the region of direct relevance to the Torres Strait and outline the SPREP-POL programme proposals.

Background

The action plan for the South Pacific Regional Environmental Programme (SPREP) was adopted at a conference on the "Human Environment in the South Pacific" in New Zealand 1982. All South Pacific States and Territories including Australia, New Zealand, as well as the United Kingdom, the United States and France participated in the SPREP Action Plan and Convention. It is considered as the overall framework for regional co-operation on environmental matters related to the marine, coastal and territorial environment of the South Pacific Region.

The Convention specifically requires the contracting parties to prevent, reduce and control pollution from any source and to co-operate in scientific research, environmental monitoring and the exchange of data and other scientific and technical information. The Action Plan and the Convention was a joint activity of the South Pacific Commission (SPC), the South Pacific Bureau for Economic Co-operation (SPEC), the Economic and Social Commission for Asia and the Pacific (ESCAP) and the United Nations Environmental Programme (UNEP).

A number of projects relevant to the monitoring, research and control of pollution in coastal and open ocean waters of the SPREP Convention area have been undertaken in the past four years, by a formally established network of research and monitoring institutions of the SPREP area with UNEP's support through a project with SPC.

On the recommendation of the Fourth Consultation Meeting of the SPREP Research and Training Institutions (Noumea, June 1988) the Intergovernmental Meeting on the SPREP Action Plan approved the consolidation of future and ongoing activities relevant to monitoring, research and control of marine pollution into a coordinated regional project called SPREP-POL.

SPREP-POL

The South Pacific Region represents a substantial area of the world's major ocean, covering an area of almost 30 million square kilometers (Morrison, 1990). Encompassed are a large number of small countries or territories separated by substantial stretches of ocean. The small size and the remoteness of many of the islands is an environmental hazard, since any mistakes in environmental management may be extremely difficult to rectify, at least in the short term.

The South Pacific has an attractive image internationally, an image that has been exploited for tourism development. The pictures of white sandy beaches, clear lagoon waters, thriving coral reef communities are used widely to attract travellers from all over the world. This picture is valid in many places, but some areas are under considerable environmental pressure. If much care is not taken, the coastal resources that form the basis of foreign exchange earning capacity may cease to be the country's lucrative source of income.

The SPREP-POL meeting in Sydney in 1989 looked at a number of reviews for the region (eg. Dahl and Baumgant, 1983; Dahl, 1984; Brodie and Morrison, 1984; Brodie *et al*, 1990) and concluded that the priority marine pollution problems are:

- Destruction of coastal ecosystems
- Lowering of water quality
- Changing ocean processes and properties
- Climate change and sea level rise.

The first three problems can be addressed directly by regional agencies and governments. The climate change and sea level rise is a global effect, not easily addressed by island nations.

The primary cause of the problems have been identified as:

1. **Disposal of domestic water (sewage and solid wastes)**

   In many countries, especially small ones, the disposal of sewage and solid wastes is difficult. If marine disposal is not to cause major pollution (both chemical and microbiological) then expensive pretreatment is required. A recent study in a number of Pacific Island Lagoons showed that contamination due to sewage was the major marine pollution problem (Naidu *et al.* 1989). The report also showed that nitrate and phosphate levels were elevated and could have adverse effects on the coral reefs.

2. **Disposal and management of non-domestic waste**

   The materials include solid waste, agricultural chemicals, waste oils and mine tailings. Pesticides have been reviewed in the region (Mowbray, 1988) as much is used on the coastal plains and washed into the marine environment. Shellfish are known to be bio-accumulators of pesticides and these accumulated toxins can present a potential health hazard. Mining is limited to only a number of countries. Ocean disposal of tailings and wastes must have an effect on the immediate environment.

3. **Increased sedimentation due to land use changes, mining and construction**

   The land use changes usually include logging projects and intensification of agriculture in the steeper zones resulting in increased sedimentation. Increased populations in coastal areas which require housing, shipping and industrial activity have also contributed to increasing sediment loads.

4. **Coastal development activities**

   These include sand and gravel extraction, dredge and fill activities, port development and tourism related activities of resort construction, airport enlargement and road upgrading. Blasting of coral reefs and mangrove removal all have had detrimental effects on the local environment.

5. **Over exploitation of living marine resources**

   This is a problem near major population centres where reef-gleaning is a major food source.

6. **Natural disasters**

   These include cyclones, volcanic eruptions and cyclical/regional events such as El Nino oscillation.

The SPREP-POL project will attempt to assess the extent of pollution and quality trends by a series of monitoring and research activities. The long term objectives of the project are:

1. To analyse the causes of marine pollution degradation in the SPREP convention area and to formulate recommendations for pollution control measures suitable for the socioeconomic development of the SPREP regions on a sustainable basis.

2. To provide the scientific and technical information needed by the Governments of the Region for the control of marine pollution as envisaged by the SPREP Convention, its protocols and the SPREP Action Plan.

3. To build up constant and comparable time series of data relevant to the state of the marine environment, including the sources, amounts, pathways levels and effects of pollutants in the SPREP Convention Area.

4. To enhance the indigenous capability for monitoring and analysis of marine pollution and informed decision making concerning the control of such pollution.

5. To contribute through the Regional Seas Programme of UNEP to the Global Environment Monitoring systems (GEMS) of UNEP.

Funding has been sought from a number of sources to support this project which is estimated to cost approximately USD $2 million over 2 years. The first $200,000 is expected to be released late 1990.

The SPREP-POL monitoring activities will include:

1. Ocean Processes and Properties

Circulation patterns, thermal structure, salinity distribution, plankton productivity, nutrient fluxes, larval distribution patterns.

2. Heavy Metals

Activities will concentrate on mercury, cadmium, lead and tin but other metals where appropriate.

3. Pesticides

In particular organochlorine pesticides.

4. Sewage related parameters

Study nutrients and microbiological contamination.

5. Hydrocarbons and detergents

A series of review papers on recent research and monitoring activities has been produced on each of the above topics for the region as an addenda to the SPREP-POL working paper. The review paper (Currey, 1990) on heavy metal monitoring includes the Fly River and Port Moresby areas of Papua New Guinea. These are of direct relevance to the Torres Strait Baseline Study.

Heavy metals in Torres Strait

Fly River Delta

The Fly River naturally discharges about 7000m^3/s of water and 85,000,000 tonnes/annum of sediment. The OK Tedi copper and gold mine has been operating since May 1984. The principal metals in the wastes are copper, lead, cadmium, and zinc. The metals are usually associated with the particulate material. Dent (1985) predicted that the copper concentrations in the sediment reaching the sea would be 320 mg/kg.

Work undertaken by OK Tedi (OTML, 1988) has shown that most of the water entering the Gulf of Papua from the Fly and Strickland Rivers flows to the northeast. Wind is the main cause of currents in surface waters of the North-Western part of the Coral Sea and through Torres Strait. This coupled with the shallow waters in Torres Strait, means part of the water discharged from the rivers into the Gulf of Papua, leaves via Torres Strait, especially during the S.E. monsoon. In the water, total copper concentrations range from >50 ug/L at Lewada, which is approximately 100km from the Gulf of Papua to <1ug/L at the Gulf. Dilution and sedimentation would cause this decrease in total metal concentration. OTML data shows that the greatest proportion of copper was found in the particulate phase. Concentrations in the water column ranged from 81 mg/kg at Lewada decreasing to 35 mg/kg, 123 km out to sea from the delta mouth. Copper in the sediments (<63 um fraction) decreased from 40 mg/kg at Lewada to 8 mg/kg 160 kilometres out to sea.

Harris (1989) analyzed 20 seabed sediments moving from the Fly Delta to 267 kilometres out to sea. The copper concentrations ranged from 22.3 - 1.1. mg/kg (Table 1). Both copper and zinc concentrations decreased on moving away from the Delta mouth. Water samples were filtered and the retained filtrate analyzed for copper. The copper concentrations ranged from 13.3 ug/L to 0.9 ug/l on moving away from the Fly River mouth.

Prawn specimens were also collected in 1986 and 1988 and analyzed for copper, zinc and cadmium. Zinc concentrations were 22 - 28 mg/kg, well below the Australian consumption recommended standard level of 150 mg/kg. Copper, with a mean of 22 mg/kg, exceeded the recommended standard level of 10 mg/kg and cadmium with a range of 0.78 - 1.86 mg/kg also exceeded the Australian consumption recommended standard of 0.2 mg/kg.

Port Moresby

Several studies have been undertaken in the Port Moresby coastal region by staff of the University of Papua New Guinea. Haei (1985) studied heavy metals in mussels, oysters and giant clams. The results (Table 2) for oysters showed low concentrations for cadmium and lead, with elevated copper (27 mg/kg and zinc (248 mg/kg) concentrations. All of the results were within the Australian recommended standards for consumable shellfish.

Kaluwin and Haei (1988) measured metal concentrations in shellfish in Port Moresby and at Bootless Bay, which is a small marina-type development. The copper and cadmium results were both elevated when compared with the previous work of Haei (1985). The zinc concentrations for all Port Moresby sites were relatively high ranging between 228-468 mg/kg, but still below the Australian recommended consumption standards of 1000 mg/kg. Balat (unpublished) measured copper in coastal sediments from 4 sites near Port Moresby. The concentrations ranged from 0.18 - 35 mg/kg dry weight (Table 1).

National Analysis Laboratory Capabilities

The National Analysis Laboratory (NAL) is a semi-commercial laboratory operating under the commercial consulting company of the PNG University of Technology in Lae, PNG. The Laboratory offers an extensive range of professional analytical testing

Table 1. Heavy Metal concentration in sediments, mg/Kg (dry weight).

SITE/LOCATION	CADMIUM	COPPER	CHROMIUM	LEAD	MERCURY	ZINC	REFERENCES
Solomon Islands (Marovo Lagoon)	0.8 - 2.6	6.2 - 164	1.1 - 86	18.7 - 79.5	na	na	Naidu *et al.*, (1989)
French Polynesia (Tahiti)	mean results 0.08 - 0.98	0.8 - 1140	9.5 - 262	<0.2 - 81	<0.05 - 5.7	35 - 339	DeNardi *et al.*, (1989)
French Polynesia (Huahine)	mean results 0.04 - 0.45	0.45 - 31	8.8 - 70	0.07 - 3.7	0.30 - 0.67	18 - 162	DeNardi *et al.*, (1989)
French Polynesia (Takapoto)	mean results 0.03 - 1.29	0.42 - 1.4	2.2 - 3.0	<0.08 - 0.98	na	0.6 - 7.5	DeNardi *et al.*, (1989)
PNG - Port Moresby	na	0.18 - 35	na	na	na	na	Balat
PNG - Fly River Delta	na	10 - 48 in <100um fraction		na	na	na	OTML (1989)
PNG - Fly River Delta	0.019 - 0.18	1.1 - 22	na	na	na	8.8 - 94	Harris (1989)
PNG - Empress August Bay	na	25 - 1500	na	na	na	na	Brodie *et al.*

Table 2. Heavy Metal concentration in Shellfish, mg/Kg (wet weight).

SITE/LOCATION	SPECIES	CADMIUM	COPPER	CHROMIUM	LEAD	MERCURY	ZINC	REFERENCES
Fiji - Laucala Bay - Suva Harbour	Crassostrea mordax	<0.1 - 0.25	15 - 161	<0.1 - 1.75	<0.5 - 5.48	<0.001 - 0.062	na	Naida *et al.* (1989)
Fiji - Vigo River estuary	Bivalves	0.03 - 0.21	1.7 - 3.0	0.34 - 0.4	0.12 - 0.18	0.01 - 0.04	6 - 10	Gangaiya *et al.* (1986)
Fiji - Teidamu River estuary	Bivalves	0.04 - 0.06	1.5 - 2.5	0.27- 0.7	0.09 - 0.15	0.02 - 0.04	7.3 - 9.0	Gangaiya *et al.* (1986)
French Polynesia Tahiti - Yacht Club	Mussels	mean results 0.14 - 0.54	5.45 - 8.0	2.0 - 8.9	0.54 - 1.96	0.09 - 0.74	93 - 590	DeNardi *et al.* (1989)
French Polynesia Takapoto	Mussels	mean results 0.45 - 3.3	3.4 - 6.7	3.1 - 19.8	0.35 - 1.35	<0.05 - 0.30	14 - 38	DeNardi *et al.* (1989)
French Polynesia Tahiti - Papeete	Mussells	mean results 0.16 - 0.31	6.7 - 38.6	2.0 - 6.85	0.67 - 2.3	0.16 - 0.40	140 - 590	DeNarid *et al.* (1989)
Vanuatu - Vila Bay Star Wharf	Crassostrea spp &	<0.01 - 0.31	32.6 - 79	<0.1 - 0.2	0.72 - 0.9	0.02	na	Naida *et al.* (1989)
Erakor lagoon International Hotel	Anadera spp	<0.01 - 0.2	13.9 - 16	<0.1 - 0.13	0.91 - 0.94	0.01	na	Naida *et al.* (1989)
PNG - Morobe	Saccostrea	0.24 - 1.0	3 - 177	na	0.03 - 0.69	na	9 - 298	Balat (1989)
PNG - Port Moresby	Saccostrea spp	0.14 - 0.43	26 - 38	na	0.11 - 0.24	na	430 - 468	Kuluwin & Haei (1988)
PNG - Port Moresby Bootless Bay	Saccostrea spp	0.23 - 0.53	51 - 98	na	0.08 - 0.81	na	236 - 279	Kuluwin & Haei (1988)
PNG - Port Moresby	Saccostrea spp	0.008 - 0.076	16.6 - 27	na	0.11	na	228 - 298	Haei (1985)
PNG - Fly River Delta	Saccostrea spp	0.1 - 1.7	9 - 191	na	0.60 - 1.2	na	10 - 4029	SPREP (1985)
PNG - Daru Bobo Island	Saccostrea spp	0.70 - 3.0	73 - 573	na	na	na	976 - 3349	Hortle *et al.* (1984)

facilities to clients in Papua New Guinea. NAL services are available to agriculture, commerce, industry, governmental departments and private individuals.

The laboratory is accredited under the PNG laboratory accredation scheme and assessed by the National Association of Testing Authorities, Australia for a wide range of analytical testing including waters, soils, sediments, biota, foliar, and foodstuffs. The laboratory has extensive experience and expertise in the following environmental fields:

- General water quality parameters to WHO drinking standards;
- Trace metals, total and dissolved in fresh and marine waters to microgram per litre detection limits;
- Microbiological examination of raw, waste and natural waters;
- Sediment and soil analysis for metals, cyanide contamination and nutrient status;
- Analysis of biological materials for trace metals including mercury.

The laboratory provides a quality service ensuring accurate and precise results. Strict quality control procedures involving the inclusion of appropriate external reference materials (NBS, IAEA and USEPA) with each analysis batch, use of quality control charts and a laboratory instrument calibration programme, ensure the accuracy and precision of results generated by the laboratory. Participation in inter-laboratory round robins such as the International Soil and Plant Exchange run by the Agricultural University at Wageningen in the Netherlands, the Association of American Cereal Chemists Stockfeed Program, the Standards Australian Cadmium and Lead in Blood program and NATA programs allow on-going verification of laboratory procedures.

NAL's location at the PNG University of Technology gives it ready access to the specialists in the University's teaching departments, as well as the Matheson Library and the University Computer Centre.

The laboratory is well equipped with state of the art instrumentation, and has a continuing programme of updating and renewing equipment. A Perkin Elmer PE3100 Atomic Absorption Spectrophotometer with flow injection and mercury amalgamation unit has been recently purchased. This will allow mercury analysis with detection limits in the region of <0.02ppb. The Perkin Elmer enhanced data system in conjunction with an IBM PC is used to provide complete control of all data handling and accessories.

Other major items of equipment in the laboratory include a Varian SpectrAA-40 atomic absorption spectrophotometer with hydride generator and graphite furnace atomizer, which is dedicated to trace metal analysis. A HPLC ion chromatography system including conductivity, fluorescence, refractive index and UV-VIS detectors, for the determination of low concentrations of anions in water samples, vitamins, sugars, organic acids etc in various foodstuffs. A PDV-2000 polarography unit allows trace metal analysis in the field. The laboratory also is equipped with standard instrumentation such as UV-Visible spectrophotometers, ion-selective electrodes, pH meters etc.

In addition, instrumentation such as gas chromatographs, FTIR and additional atomic absorption spectrophotometers are available in the Department of Applied Science, ensuring a wide range of analytical techniques to meet specific or customized analysis requirements according to clients needs.

All trace metal analysis sample preparation is performed in the laboratory's clean room facilities, which include laminar flow cabinets, and a Barnstead high purity water system. The use of over-shoes, tacky mats, particulate free laboratory coats and gloves by personnel in the clean room environment ensure contamination free preparation of samples for trace metal analysis.

The clean room facilities are of particular importance. Furness and Rainbow (1990) in their authorative volume on trace metals in the marine environment, point out that major advances in knowledge of the concentrations and distributions of trace metals in the seas and oceans have only occurred since the mid 1970s. This is largely due to the adoption of clean methodologies for handling and analysis of samples.

NAL currently provides an environmental testing service to many major clients including Placer Pacific in their environmental baseline studies and ongoing compliance monitoring at Porgera and Misima Island gold mines. The laboratory has performed the majority of the analyses for the pre-mining environmental impact statements undertaking by Natural Systems Research, environmental consultants for the majority of the mining developments in Papua New Guinea.

Other projects conducted by NAL staff have included studies for SPREP on "Monitoring of Papua New Guinea Waters Receiving Inputs from the Mining Industry" (Hilton *et al*, 1988) and investigations into metal concentrations of waters, sediments and biota from Lake Murray and the Strickland River (Currey and Yaru 1990). Currently, a paper titled "Total As, Cd, Cu, Cr, Fe, Hg, Mn, Ni, Pb, Se, and Zn Concentrations in Barramundi, *Lates calcarifer*, from Lake Murray, Papua New Guinea" (Currey *et al*, 1990) is to be published in the *Science of the Total Environment* journal.

Conclusion

The PNG University of Technology through its ongoing research programmes, has the ability to input a significant contribution to the Torres Strait Baseline Study. The National Analysis Laboratory has the proven capability and expertise to undertake the analysis of waters, sediments and biota for trace metals including mercury and the metalloids arsenic and selenium.

SPREP coordinators are willing to be associated with the Torres Strait Baseline Study which in conjunction with the SPREP-POL project, can monitor marine pollution in a concerted regional effort, producing a comparable time series of data. This will produce valuable information for governments, allowing timely and cost-effective action to correct pollution problems, and to plan for sustainable development and management.

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