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PREFACE

GESAMP, the Joint Group of Experts on the Scientific Aspects of Marine Pollution, was established in 1969 and is today co-sponsored by the International Maritime Organization (IMO), Food and Agriculture Organization of the United Nations (FAO), United Nations Educational, Scientific and Cultural Organization (UNESCO), World Meteorological Organization (WMO), World Health Organization (WHO), International Atomic Energy Agency (IAEA), United Nations and United Nations Environment Programme (UNEP). According to its present terms of reference, the functions of GESAMP are:

- to provide advice relating to the scientific aspects of marine pollution [1]; and
- to prepare periodic reviews of the state of the marine environment as regards marine pollution and to identify problem areas requiring special attention.

Since its beginning GESAMP involved a large number of experts as members of GESAMP or GESAMP Working Groups and produced, at the request of the sponsoring organizations, numerous reports [2].

This document reproduces the substantive part of the report of the GESAMP Working Group on Interchange of Pollutants between the Atmosphere and the Oceans, approved by the fifteenth session of GESAMP (New York, 25 - 29 March 1985).

At the request of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona, 1976) the WMO-led GESAMP Working Group on the Interchange of Pollutants between the Atmosphere and the Oceans in 1981 was invited to describe air pollutent transport processes towards and into the Mediterranean Sea (including horizontal atmospheric transport affecting the region, vertical atmospheric transport to the air-water interface and air-water interchange) and to review the scientific literature and assess the pathways and fluxes of important contaminants into the Mediterranean region.

To tackle these tasks the Working Group held three meetings in 1982 in Monte Carlo, in 1983 and in 1985 in Athens. At the Monte Carlo meeting a conceptual model was developed as regards atmospheric transport processes towards the Mediterranean Sea which included a general strategy of relevant activities, recommendations on suitable monitoring sites, model approaches and a pilot contaminant - cadmium, on sampling and analytical methodologies and data handling.

1/ GESAMP defined marine pollution as "introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrence to marine activities including fishing, impairment of quality for use of sea-water, and reduction of amenities."

2/ V. Pravdic: GESAMP, The First Dozen Years. UNEP, 1981.

At the Athens meeting in 1983, model approaches and the data requirements for the applications of dispersion models enabling to estimate the flux of contaminants (heavy metals) from the atmosphere into the sea were discussed in detail and a general framework was formulated of a pilot project for the study of the atmospheric transport of contaminants into the Mediterranean.

A review of the knowledge of the physical, chemical and biological processes, which control the air-sea exchange of contaminants, and of the results of relevant research conducted in the Mediterranean along with a brief description of existing programmes in other regions were made at the expert consultation held in Athens in 1985. At that meeting the outcomes of two previous meetings were also generalized and the present report entitled "The Atmospheric Transport of Contaminants into the Mediterranean Region" was prepared.

The Third Meeting of the Working Group for Scientific and Technical Co-operation for MED POL (Athens, May 1985) recommended to initiate in 1986 a pilot -project on "studying air pollutant deposition into the Mediterranean region and pollutant concentrations in air" using this report as a basis for such a pilot project.

The activities of the GESAMP Working Group on Interchange of Pollutants between the Atmosphere and the Oceans were organized by the World Meteorological Organisation (WMO), acting as the "lead agency". Financial support for the Working Group was provided by WMO and UNEP.

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1. EXECUTIVE SUMMARY

Since the eleventh session of GESAMP, at the request of UNEP, the Working Group on the Interchange of Pollutants Between the Atmosphere and The Oceans (INTERPOLL) focused its terms of reference on the description of transport processes towards and into specific regions. Using the Mediterranean as a model of a semi-enclosed sea, the Group examined horizontal atmospheric transport, vertical atmospheric transport to the air/water interface, and the interchange at this boundary. The Working Group also reviewed the scientific literature pertinent to this problem. During its fourth and fifth sessions which took place in Monaco in 1982 and in Athens in 1983, the Working Group discussed the specific requirements of the MED POL programme and made relevant recommendations. The reports of these two sessions were analyzed during the present meeting and used, along with more recent data, to produce the present interim report on atmospheric transport of contaminants into the Mediterranean Region.

The first part of this report provides a review of the knowledge of the physical, chemical and biological processes, which control the air-sea exchange of contaminants, along with a brief description of existing programmes in the Pacific Ocean, the North Atlantic, the Baltic Sea, the North Sea and the Mediterranean Sea. The second part of the report discusses existing works relevant to the Mediterranean area. A limited data base exists for contamination of marine concern, with most information on air concentrations of heavy metals (particularly Cd and Pb), PCB's and n-alkanes, and very little information on concentrations in precipitation. The available data indicate that levels of atmospheric contamination over the Mediteranean are comparable to those over other European regional seas. Indirect evidence, based on the association of some metals (eg. Cd, Pb) with submicrometer-sized particles, and direct evidence based on the transuranic content of Mediterranean rains, suggest that the sources for some atmospheric contaminants transported into the Mediterranean Sea are quite distant. Natural inputs of some metals (on a regional or episodic basis) into the Mediterranean atmosphere were also considered to be important. These include volcanic activity and soil erosion particularly from the Sahara. Flux estimates for some elements, such as Hg, Cd, Pb, Cr, and transuranic elements, indicate that the atmospheric transport of contaminants is at least comparable in magnitude to riverine inputs into the Mediterranean.

Evaluating the pathways of contaminants to the region requires a comprehensive understanding of climatology and meteorology of the region. An analysis of nine years of back trajectories to the western Mediterranean showed that northerly flow took place 30% of the time with relatively large changes from year to year and with no significant seasonal variation. Also the number of the trajectories from the south was greater in the early summer and this transport would be expected to bring desert dust particles during this period. In the eastern part of the basin, the trajectories climatology shows that flow from the north and northwest is predominant.

To assess the contributions of different source regions to the concentrations and deposition in the Mediterranean area, the application of a mathematical model is strongly advised. Detailed suggestions with regard to one type of model for long range transport and its application are given.

The Working Group recognized the problems in assessing atmospheric pollutant input into the Mediterranean, identifying in particular the need for more quantitative information on emission sources of pollutants in the region, local climatological data, transport pathways and air-sea exchange rates of pollutants. A strategy for such an assessment was developed in which Cd, was recommended as an appropriate substance for study in a pilot project. For such a pilot project, sampling sites, sampling methodology and analytical techniquss have been suggested.

2. INTRODUCTION

The fields of marine chemistry and marine contamination have long been concerned with understanding the budgets of chemical species in the oceans and the geochemical cycles of these elements. Initially, research focused on the most obvious input flux to the oceans - that borne by rivers. However, it is now recognized that a substantial fraction of the contamination entering the ocean derives from sources located on land via atmospheric input (NAS, 1978; Waldichuk, 1982). Contaminants of major concern are heavy metals and matalloids such as Pb, Cd, Hg, As, and Sn, petroleum hydrocarbons, chlorinated hydrocarbons and pathogenic microorganisms. Such elements or substances are present in the air in the particulate form and/or in the gaseous form. The atmospheric lifetime of such materials is generally long enough (greater than 1 day) to allow them to be transported far from their sources (greater than 1000 km). On the other hand, these lifetimes are often too short (less than 1 year) to allow uniform horizontal and vertical mixing of contaminant material in the global atmosphere.

The study of atmospheric transport to the sea is in many ways analogous to the study of river transport. In both cases there is a common objective, that of defining the temporal variability of the flux - how does the source output vary with climate and human activity? An understanding of this variability is essential if we are to characterize the present day flux. The characterization of the temporal and areal variability of the continent-to-ocean wind-borne flux is a difficult task. In contrast to rivers, which have well-defined channels and are relatively shallow, the winds are global in scope and they have significant vertical structure. Thus, in order to quantify atmospheric transport, it is necessary to develop a comprehensive understanding of the governing meteorological processes, such as wind flow and precipitation patterns, and to evaluate their effects on the chemical fluxes.

2.1 Transport Processes

2.1.1. Horizontal Transport

In the simplest sense, atmospheric transport to the ocean, as seen from a meteorological perspective, can be regarded as occurring in two different scales: off-shore and long range (NAS, 1978).