Amity Journal of Energy & Environment Studies
2016, Volume 2, Number 1

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Amity University Uttar Pradesh, Noida Campus (ISSN 2454-7778)

Ocean Pollution and its Various Hazards – An Overview

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The contamination in an ecosystem causing harmful impact on the organisms in that ecosystem is called pollution. It can be done by changing the growth rate and reproduction of plants or animal species, or by human interfering for their comfort, health or property values. The term contamination or pollution also includes any physical modification that alters the energy and radiation flow in an environment.

Keywords: Oceanpollution, environment, marine pollution, ecosystem, disposal system, pollution, emissions, spilling.

INTRODUCTION

Sewage disposal into the ocean has come a long way from the time when there was indiscriminate dumping of wastes. The alarming ocean pollution that resulted from such practice has, in most places, been virtually eliminated in recent years. Today disposal is a carefully controlled operation based on extensive engineering research and design. However, up until 10 years ago it was the usual practice to discharge sewage effluent from the end of a pipe or submarine outfall in a single large stream. The buoyancy of such a flow was so strong in relation to its mixing rate that the effluent plume would invariably rise to the surface and spread as a surface current. Pollution of the shoreline was likely when onshore currents occurred.

Objective

- To describe the various hazards caused by ocean pollution.
- To get the knowledge of how the ocean pollution is calculated.
- To define the solutions that are used to resolve the problem of the ocean pollution.

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Ocean pollution vs Marine pollution?

Marine pollution or Ocean pollution is defined by the Group of Experts on the Scientific Aspect of Marine Pollution (GESAMP), as part of the basic framework of the UN Convention On the Law of the Sea (UNCLOS) 1982 (Article 1.4), is: "the introduction by humans, directly or indirectly, of substances or energy into the marine environment resulting in such deleterious effect as harm to living resources, hazard to human health, hindrance to marine activities including finishing, impairment of quality for use of sea water, and reduction of amenities."

How is it caused?

In Fig. 2 and Table 1 we show the relationship between shallow cloud cover and the presence of aerosols in all four geographical zones analyzed separately for each of the 3 months of this study. Cloud resolving models predict an increase in strati form cloud cover with an increase in the aerosol concentration. However, cloud properties also change because of variation in large-scale atmospheric circulation that may also affect aerosol concentrations. For example, regions of low atmospheric pressures are convergence zones that tend to accumulate aerosol and water vapour and generate conditions favorable for cloud formation. To untangle the effect of aerosol and large-scale meteorology on cloud properties, weuselinear multipleregression. Note that the aerosol indirect effect can not beuntangled with high degree of confidence until regional models can predict cloud evolution with high precision. Here we are mainly trying to eliminate the influence of large-scale meteorological parameters that can impact simultaneously both aerosol concentration and cloud development, generating false correlation between them. The regression analyzes the dependence of the measured cloud properties (cover, droplet effective radius, and optical thickness) on:

(i) MODIS measurements: aerosol optical thickness (AOT) and total perceptible water vapor (indicator of convergence);

(ii) National Center for Environmental Prediction (NCEP) generated meteorological fields that include air temperature at 1,000 hPa, temperature difference of 850 and 1,000 hPa and 750–1,000 hPa, winds at three altitudes (1,000, 750, and 500 hPa), broad-scale vertical motion at 850 and 500 hPa based on the continuity equation, sea surface temperature, equivalent potential temperature difference between 500 and 950hPa, and lowstatic stability, where the differential is defined as a finite difference between 850 and 950 hPa. The logarithm of the AOT is used to reduce nonlinearity in the regression. Logarithmic dependence is expected from cloud condensation theory, and it was found to be appropriate here. Nonlinearity in the relationships among the parameters may reduce the efficiency of the multiple regressions.

Fig. point source and nonpoint source pollution

Fig1. Classification of pollution forms.

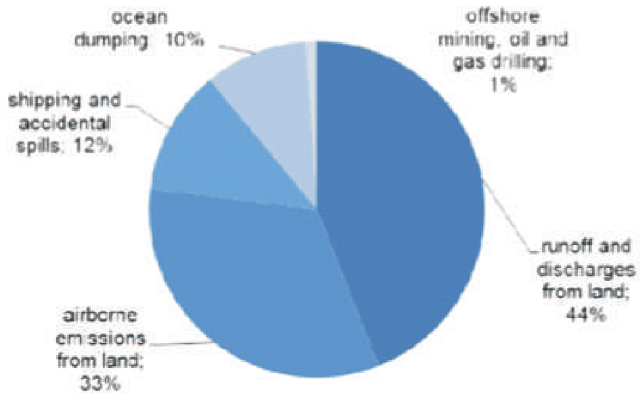


Fig 2. Share of Difference sources of Ocean pollution

The pollution in the ocean and seas are originated from four distinct sources, which are:

- Through runoff and disharges form land,
- Airborne emissions from the land,
- Shipping and accidental spilling,
- Ocean dumping

The percentage of these activities is shown in the pie chart of Fig 2

Lastly, there are the large chunks of plastic that are being dumped along the coast, in rivers, etc…. Once they arrive in the ocean, they float along on the oceanic gyre which concentrates this kind of debris in the different oceans. This waste material is the main killer of life in the ocean and may take up to 450 years to be degraded.

How to measure the pollution an analysis?

Analysis of the Satellite Data uses the MODIS data on the Terra satellite to measure the daily aerosol column concentration and its correlation to the1° latitude and longitude grid. Simultaneous observations of aerosols in cloud-free regions of the grid box and clouds in the cloudy regions of the grid box are possible (see http:modisatmos.gsfc.nasa.gov). Aerosol non homogeneity has a spatial scale of 50–400 km, allowing the 1° resolution study. MODIS measures the aerosoloptical thickness, (in cloud-free, sun-glint-free conditions),representing the aerosol column concentration, which we use as a surrogate for the concentration of aerosol that interacts with the cloud layer. MODIS also measures the following cloud properties: cloud cover, optical depth, liquid water content, cloud top effective radius, and cloud top pressure. The 1° latitude and longitude data were classified as shallow water clouds if the average cloud top pressure is higher than 640 hPa and all of the clouds in the given grid box and in its surrounding neighboring pixels are water clouds (noise).The average cloud top pressure of the shallow clouds is 870 hPa, corresponding to 1,200 m. For the region impacted by smoke, 53% of the 1° grid boxes were classified as shallow clouds (see Table 1). This percentage corresponds to 107 km2 with average of 50 daily observations during the 3 months of investigation. For the region impacted by dust it corresponds to 106 km2 of observations (see definition of the studied region in Table 1). Results during June through August, smoke, dust and pollution aerosols are confined to separate latitude belts of the Atlantic Ocean, allowing separate analysis of their effect and the effect of pure marine air on the prevailing clouds (see Table 1). Fig. 2 shows the longitudinal distribution of changes in the shallow cloud cover and in the effective radius (Reff) from clean to aerosol-lade conditions. The fraction of the shallow clouds decreases from east to west because of transition from shallow to convective clouds. The largest changes in cloud cover are observed in regions with high aerosol concentrations near the continental sources. The cloud liquid water path (LWP) increases in all but the biomass burning zone, in agreement with theory.In the smoke zone the LWP decreases. The satellite data show a systematic increase in the shallow cloud coverage as a function of the aerosol concentration across the Atlantic Ocean for all four aerosol types (see Table 1). For a given value of cloud fraction (0.30), the spatial coverage of shallow clouds extends 2,000 km further to the west for heavy smoke or dust in comparison with the clean conditions.

Table 1. Results of the analysis for four regions in the Atlantic Ocean

Region	Dominant aerosol	Fraction of region	Shallow cloud cover	Range of AOT	Mean AOT	Δcl-aer	δcl-aer	% change in R_{eff}	% change in LWP	Change in CLTP, hPa	Radiative effects (W/m^2) due to ΔN_c	ΔN_c + ΔLWP	ΔN_c + ΔLWP + δcl	Total forcing TOA	ΔAbs
30°N-60°N	Pollution	0.17	0.07	0.03-0.19	0.102	0.20 ± 0.06	0.19 ± 0.03	−12 ± 10	6 ± 34	−39 ± 20	−1.0	−1.1	−4.5	−8.0	0.7
5°N-30°N	Saharan dust	0.26	0.11	0.03-0.46	0.174	0.36 ± 0.12	0.25 ± 0.04	−12 ± 13	9 ± 34	−66 ± 13	−0.7	−0.9	−6.8	−14.0	0.7
20°S-5°N	Biomass burning	0.53	0.29	0.03-0.43	0.152	0.31 ± 0.07	0.31 ± 0.04	−32 ± 3	−21 ± 8	−55 ± 11	−1.5	−1.0	−9.5	−11.3	2.9
30°S-20°S	Marine	0.47	0.27	0.02-0.24	0.085	0.45 ± 0.10	0.45 ± 0.04	−19 ± 7	35 ± 22	−72 ± 18	—	—	—	—	—

Columns from left: location; dominant aerosol; fraction of the region classified as shallow clouds; shallow cloud fraction; range of the AOT in the analysis (5th, clean, and 95th, hazy percentile), mean value; Δcl-aer, change in the cloud cover from the clean and hazy conditions; δcl-aer, partial change in the cloud cover associated with aerosol by the multiple regression; % change in the cloud effective radius (R_{eff}) from the clean and hazy conditions; % change in the cloud liquid water content (LWP); change in the cloud top pressure (CLTP). For each value the variability among the three months of analysis (June-August) is given. The average radiative effects due to change in the aerosol optical thickness from the base oceanic value of 0.06 associated with the following: increase in cloud droplet concentration (ΔN_c) due to reduction in R_{eff}; + change in the column cloud water content (ΔLWP); + change in the cloud cover (δcl); + direct aerosol radiative effect at the top of the atmosphere (TOA); ΔAbs, absorption of sunlight by aerosol. Note that the sum of the last two columns is the total aerosol radiative forcing at the surface. The radiative effect was calculated as half of the effect for solar zenith angle of 60° only for 1° latitude grid boxes characterized as shallow clouds. The uncertainty in the aerosol measurements from MODIS is ~10%, cloud fraction ~3%, and cloud effective radius 20%. The 95th percentile confidence limit of the multiple regression is 4–8% off the stated values. The overall error in the radiative effects calculations is therefore ~20%. Absorption computations depend on the validity of the assumed single scattering albedo with uncertainty of 50%. No calculations are given for the marine region, because the average AOT is too close to the baseline value.

LITERATURE REVIEW

The marine environment and the river environment can be easily monitored by the applications which are wireless sensors. Planet Earth comprises of 70% of ocean, this does not include the rivers and the lakes that we have as a critical part to our well-being. The use of non-renewable resources has been increased drastically over the years, for which the search of the oil reserves is going deeper and deeper into the water bodies. The transportation of the crude oil and the oil products across the globe is done with the help of large tankers. This at times results into oil spill, which pose a serious threat to the economy of the world. Due to such large amount of oil being transported the quality spilled annually is also very large. It is estimated that 4.5 million tons of oil is spilled in a year. The biggest contribution done to the ocean pollution is done by the tankers that travelling beyond the oceans i.e., roughly 45%. The other sources that caused the same problem is the land based sources such as the urban waste and industrial discharges, which reach the ocean through rivers. Keeping a check on the marine environment is very difficult as well as costly to the humans. It causes drivers to keep a regulatory check for hours including the other facilities they require. They need to work on the days when the weather won't be supporting them. Due to the technological advancement humans have come up with the wireless network models for the underwater status checking here the Autonomous Underwater Vehicles (AUV), Unmanned Undersea Vehicle (UUV) and Buoys are used to extract the data and analyses it at the base station.

1. *Through runoff from the land*

The pollution mainly transport from the land to the ocean via rivers. The different forms of waste material from land are taken up by the river which ends up in the oceans. The most of polluting materials come from the urban areas, and the industrial sewages that are placed in the river and end up meeting the ocean(s). This urban and industrial sewage together with agricultural run-off, does contains high levels of nitrogen and phosphorus, which is essential for any life to being. But these elements are present in ocean at very limited concentration to allow for abundant organismal growth. A content of nutrient-rich water from land can therefore upset any balance in the aquatic ecosystem in

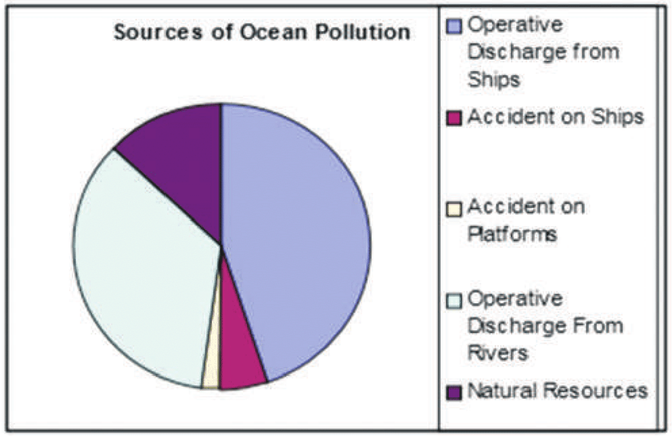


Fig 3: Source of Ocean Pollution

coastal areas. Due the rise in the level of nitrogen and phosphorus, the microalgae populations finds themselves at a very low level of restrained in their growth. This often result in so called algal blooms; which is massive growth if the unicellular algae in the sea. The dead are easily mineralized in water and same happens with the unicellular algae. Their remains are then decomposed/ mineralized by bacteria, which thereby consumes much more oxygen than they require, making the water beneath becomes anaerobic. Resulting into the death of any fish or any invertebrate life there. So the sewages cause such a distortion to the balance of marine ecosystem.

There is another runoff from dust particles coming from metal ore and metal mines, washing away in the rivers. The metabolism of plants and animals are then affected by these metals. According to the US Environment Protection Agency (EPA), more than 40% of watershed contains metals in the western continental of US, of which large portion ends up in the oceans.

2. *Airborne emissions from the land*

Airborne emission or the atmospheric pollution is another way for polluting the ocean. The light dust fractions and debris are taken by the wind and blown towards the ocean. A large number of dust particles carrying metal traces lands up into the oceans and hence pollute the same.

The secondly, atmospheric pollution that effect the oceans environment are the greenhouse gases. These gases are slowly and steadily warming the earth and hence increasing the temperature of oceans. Not only this, there is increase in the concentration of carbon-dioxide (CO2) in the atmosphere which results in the acidification of the ocean. The engine vehicles use combustive gases which gives the output as sulphur-dioxide (SO2) and nitrogen-dioxide (NO2). These gases are the most dangerous gas that result in the production of acid rain.

3. *Shipping and accidental spilling*

Shipping is an activity that effect the ocean environment in two ways, first, the engine of the ship as well as the incineration of the garbage produces carbon-dioxide, sulphur-dioxide and nitrogen-dioxide, which adds to global warming and to the acid rain formation. Secondly, the cooling system of the ship is operates on many harmful and flammable gases. The escape of these gases builds up the chlorofluorocarbons (CFCs) which is very harmful as it depletes the ozone layer of the earth.

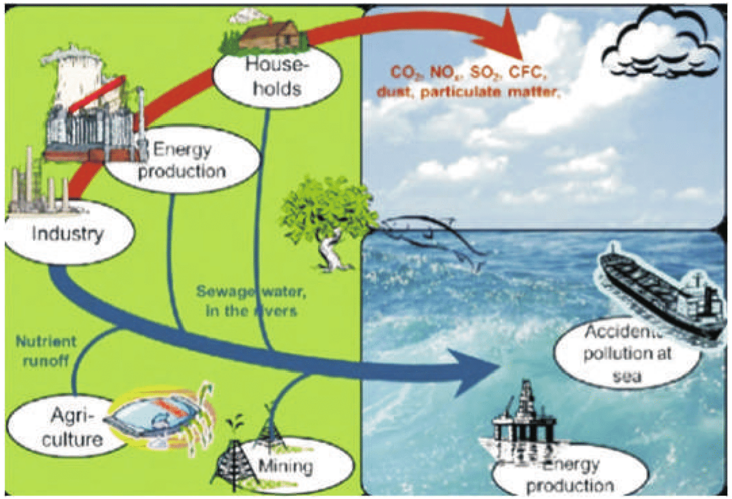


Fig 4. Inputs of pollution into the marine environment

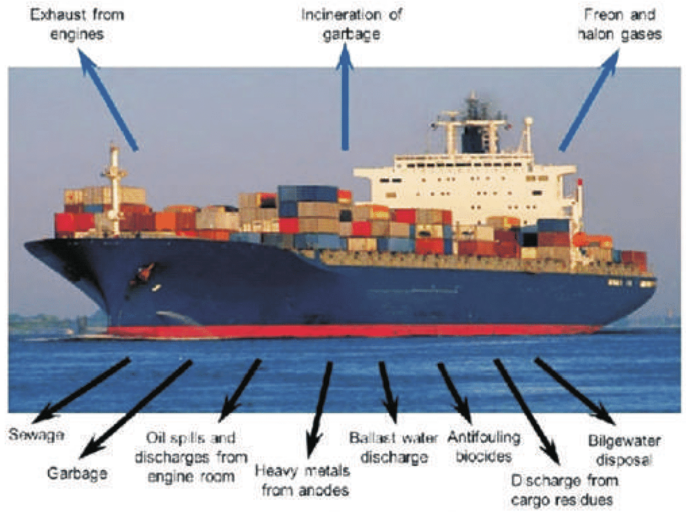


Fig 5. Shipping and Accidental Spilling

Most of marine pollution is simply by accident: When it comes to the amount of pollution that goes into the water, it needs to be said that most of it is simply by accident. As there are a good number of international regulations that forbid express dumping of all different kinds of waste above certain levels. For example, garbage has to be either delivered to shore or burnt in incinerators onboard. Incineration is prohibited in special area. The quantitatively largest aquatic form of accidental pollution caused by the maritime sector is also the one that has been highlighted the most: oil spills. As crude oil consists of a wide range of different hydrocarbon molecules with different molecular weight and properties, it is not easy to give a concise view of the total damage that is done by an accidental spill. Apart from the highly visible heavy oil that covers the water, the animals and the shores, a large number of lighter components are present as well. These lighter components are likely to do even more damage in the long run, as they are stored in the adipose tissue of different animals in the food chain. Examples of these lighter components comprise the monocyclic and polycyclic aromatic hydrocarbons, which are difficult to clean up, and bound to cause cancer and other health problems after a few years of continuous exposure.

Biological contamination, the risk for biological contamination is most tricky to contend with. To start with, when ballast water is taken up, it is bound to contain a number of microscopic life forms, such as algae and larval forms of invertebrates that belong to the specific region the ship resides in. When the ballast water is pumped out, possibly even after a few weeks, organisms may end up thousands of kilometres away from the region where they belong.

Similarly, there are the organisms that attach themselves to the ship hull in a process called biofouling. Calcareous fouling organisms (protected by a calcium-enforced exoshell) include barnacles, bryozoans, molluscs, polychaetes and tube worms. Examples of non-calcareous (soft) fouling organisms are seaweed, hydroids, algae and bacterial biofilms. Together, these organisms form fouling communities on all kinds of maritime objects. Roughly 90% of the species that are transported unknowingly does not survive the transition to a new habitat. The remaining 10% is able to stay alive and happens to be seen now and then. They cause no harm whatsoever. 1% of the transported species, however, is able to establish a firm presence in its new home. These are called exotic species, or, with a more popular term, “aquatic hitch hikers”. About 10% of these exotics even end up threatening the normal ecological processes around them, chasing the local (endemic) organisms out of their habitat and niche, taking over the region, spreading new diseases, etc

4. *Deep sea mining*

A last source of pollution is deep sea mining. This process attempts to unearth the deposits of sulfides and important and precious metals (such as silver, manganese, copper, gold and zinc), which are often created near hydrothermal vents, at about 1400–3700 m below the ocean surface. The mining occurs with hydraulic pumps and buckets being taken up and down to reach the ores and transport them to the surface. It should not be surprising that nations and companies turn to the sea to enhance their metal production. Ore mining on land has been going on for decades, if not for centuries, and many mines are being overtaxed already, if not bordering on complete exhaustion. Moreover, the time seems right for an economically viable exploitation of the metal ores on the ocean floor:

- A lot of the necessary technology is available, reducing the risk and the initial investments to be made; e.g. cables to be laid at such a depth, diamond drills available from deep water oil and gas mining
- Also, metal prices are high and still rising, leading to a substantial and certified return on investment.
- And lastly, there is an apparent shift in focus from the international waters (and their highly regulated status) towards the exclusive economic zones, controlled by individual states.

During June through August, the Atlantic Ocean is covered by varying concentrations of several aerosol types, each covering a separate latitude belt. The Southern Tropical Atlantic (30°S–20°S) is dominated by clean maritime air. The region between 20°S and 5°N is a relatively well defined region covered by smoke from biomass burning in Africa. The Northern Tropical Atlantic (5°N–30°N) is under heavy influx of dust from Africa, and the Northern Atlantic (30°N–60°N) is impacted by anthropogenic pollution aerosol from North America and Europe. These aerosols absorb and reflect solar radiation to space,there by affecting the regional atmospheric energy balance. Clouds that form in air laden with high aerosol concentrations tend to contain more numerous but smaller droplets that reflect sunlight and cool the Earth.The smaller cloud droplets reduce the efficiency of droplet growth by collision coalescence, which at least under some conditions reduce precipitation formation and increase cloud lifetime. However, there is a second pathway for aerosols to affect clouds: Smoke, pollution, and dust aerosols absorb solar radiation, heat the atmosphere, and reduce evaporation from the surface. As a result, smoke over the Amazon or pollution

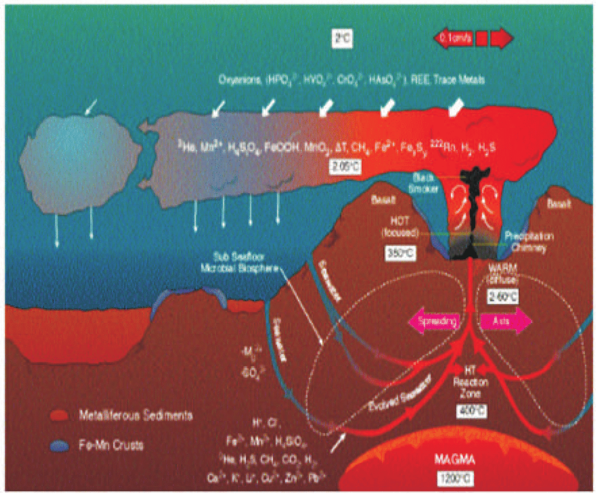


Fig 6. Deep Sea Mining

aerosol over the Indian Ocean can inhibit cloud formation.This "semi direct effect" was initially predicted global warming effect, but recent studies questioned this conclusion. Cloud-resolving models show that absorbing aerosols located above stratified clouds can strengthen the temperature inversion, thus increasing the moisture and liquid water content of the cloud layer. Here we present observations of yeta strongereffect of aerosols on clouds and climate, namely, a substantial increase in shallow cloud coverage due to high aerosol concentrations.

SOLUTIONS FORMULATED

How to control the pollution?

Sewage disposal systems

Generally, sewage disposal systems involve collection, treatment, and dispersion. All water used in man's activities ultimately must be returned to the water environment, unless evaporated. In large metropolitan areas domestic sewage and industrial wastes are collected by a system of sewers to central locations where the treatment and ultimate disposal can be closely controlled by engineers. It is interesting to note that one of the difficult problems of air pollution is that it is impractical to collect "used" air on a community-wide basis for treatment and disposal; instead we must impose directly on the con- summer (such as the owner of an automobile) some responsibility for control of air pollution. Strict rules prohibit industries from dumping in- to the sewers any highly obnoxious wastes which would have an adverse effect on either the ocean or the treatment plant operation. Furthermore, storm water must be excluded because it would grossly overtax the sanitary sewer system. For example, the daily mean flow of 308 million gallons collected by the County Sanitation Districts is equivalent to only 0.03 inch in water depth per day distributed over the drainage area. When it rains several inches in one day, the storm runoff may be tens of times larger than the flow which can be taken in the sanitary sewers. It is unfortunate that many Eastern cities have sewers that allow the sanitary sewage to become mixed with the storm run-off, and to over- flow into the natural watercourses whenever sewage treatment plants cannot handle the huge flows.

Ocean disposal

To plan a new system for ocean sewage disposal the engineer must start by considering the water quality standards to be met in the ocean environment-including maximum allowable bacteria concentrations, maximum increase in turbidity,

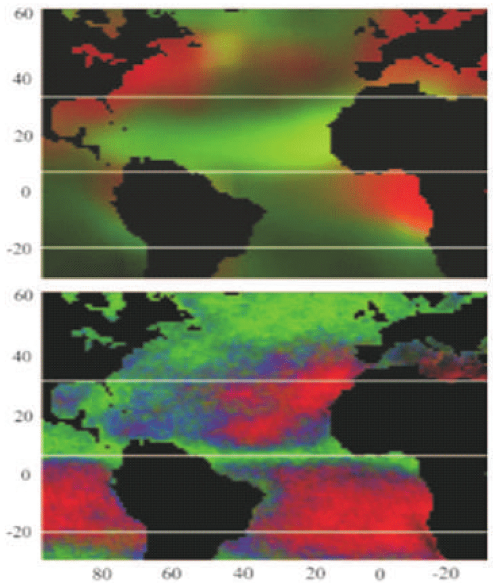


Fig 7. Spatial Distribution of aerosol and clouds over the atlantic ocean from moderate resolution

limitations on any grease, absence of odours, minimum dissolved oxygen, absence of floating or suspended solids of recognizable sewage origin, or any other aesthetically unacceptable condition. The State of California, for example, has many detailed and strict requirements related to all of the foregoing characteristics; nonetheless, huge quantities of sewage effluent may be dispersed from properly controlled outfall systems without pollution. Usually only primary treatment of sewage and industrial wastes is required, as in the case of the two large Los Angeles systems and the new San Diego sewerage system. Such treatment includes screening; sedimentation for removal of settles able solids, floatable solids, and grease; and chlorination if required for control of bacteria and viruses. The City of Los Angeles and the City of San Diego do not have to chlorinate at all to meet the rigid bacterial requirements of the state, while the County Sanitation Districts chlorinates its effluent only for a few days in the winter when the stratification in the ocean disappears. In all cases the dilution of the effluents with seawater is so great that all the other standards are very easily met after just the primary treatment. The solids or sludge collected in the treatment plant are subjected to anaerobic decomposition in large digestion tanks, where sludge is reduced to a relatively stable humus-like liquid material of very fine particles in suspension. There is insufficient demand for all the digested sludge as fertilizer, so it is often pumped to the ocean also, either through a separate small outfall (as for the City of Los Angeles) or mixed with the sewage effluent (as by the County Sanitation Districts). In neither instance has the build-up of deposits the bottom been progressive, because organisms and currents cause a gradual disappearance or assimilation into the natural bottom sediments. The turbulent diffusion of the sewage effluent occurs in 2 stages. 1st there is the jet or fume mixing near the diffuser pipes, which is controlled by the nature of the manmade diffuser

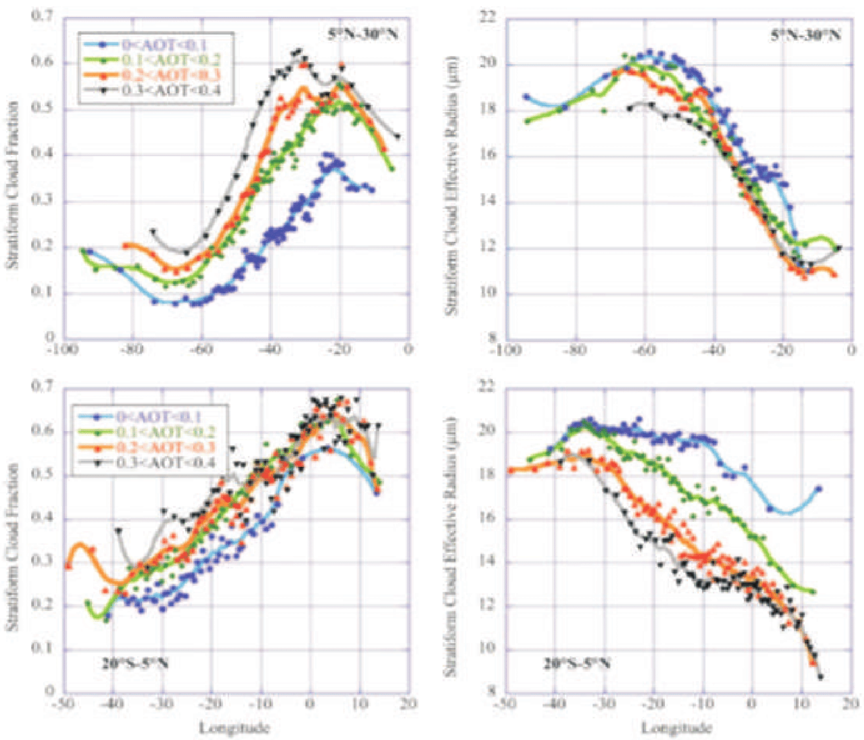
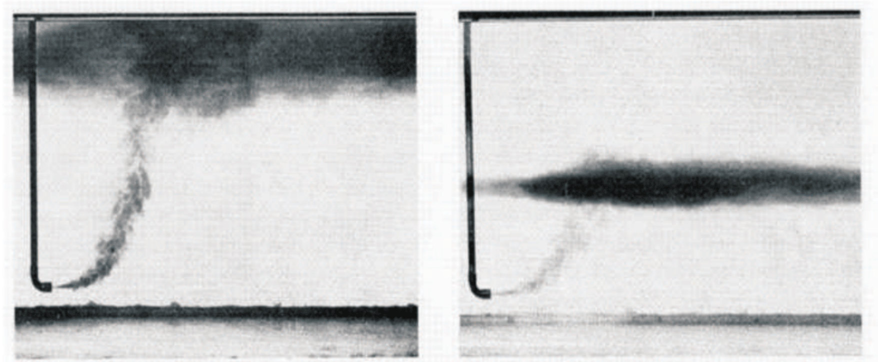


Fig 8. Longitudinal dependence of the shallow cloud fraction and droplet effective radius fro the northern tropical atlantik with dust instrusions and southern tropical atlantic with smoke instusion.



These two laboratory tank experiments illustrate the effect of density stratification in the water. Above, the water is of uniform density, and the buoyant plume rises to the surface. However, a slight density layering in the water stops the rising plume and keeps the cloud completely submerged.

Fig 9.Effecr of density stratification

pipes, which is controlled but her nature of the manmade diffuser. 2nd is the moment of the diluted sewage "cloud" by the ocean turbulence. For the greatest security unit is good practice to achieve as much manmade mixing as feasible right at the diffuser and to avoid depending too heavily on the natural dispersive mechanism of the ocean, which are more difficult to predict analytically and statically. Diffuser pipes are oriented, within allowable and spacing of ports is based on consideration of the behavior of the buoyant jets discharged from the ports. The port diameters are selected to make the "inside" hydraulics of the diffuser correct for a good manifold.

Effect of density stratification

A remarkable change in the flow pattern occurs where there is a slight gradation of density in the ambient fluid, caused by temperature and salinity changes with depth. In the ocean the stratification is almost always hydro dynamically stable, with warmer layers at the top. In the laboratory, the ambient salt water is stratified by filling the tank very slowly with thin layers of progressively decreasing salt content at the same temperature; the "staircase" variation of density is soon smoothed into a uniform gradient by molecular diffusion.

CONCLUSION

There have been two significant advances in techniques of sewage disposal into the ocean. First, the natural density stratification of the ocean has been used to great benefit in keeping waste discharges submerged in the lower layers of the ocean. Second, very large multiple-jet diffusers have been successfully designed and operated without clogging or mal-distribution of flow. Diffusers greatly increase the dilution of sewage effluent with seawater, and dilutions of 200 parts of seawater to one part of sewage effluent are now commonly achieved. It is only by this new technique of using a large number of small, widely-spaced jets that full advantage can be taken of the slight but definite density stratification patterns in the ocean

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