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Evaluation of the effectiveness of the regulatory regime in the management of oil pollution in Kenya

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ABSTRACT

This paper presents an evaluation of the effectiveness of the regulatory regime in the management of oil pollution on Kenya's marine and coastal environment. The prospect of chronic oil pollution along the Kenyan coastline and the port of Mombasa is discussed. A review of the vulnerable marine and coastal resources, commonly used indicators of effectiveness in oil pollution management and the legislation governing oil pollution is given. The author concludes by emphasising that despite having the right legislation in place, there is need for the establishment of criteria and indicators necessary for evaluation of policy effectiveness.

1. Introduction

Kenya has an Indian Ocean coastline that extends for approximately 600 km, between latitudes 1°41′ S from the Somalia border in the north and 4°40′ S from the Tanzanian border in the south, respectively (Fig. 1). The coastline is part of a major shipping route for large petroleum and oil tankers transporting these products from the Middle East to other parts of the world. The major Kenyan port, Mombasa, links the country with eastern and central African countries and the rest of the world. The port handles a substantial number of ocean-going ships (including oil tankers) and other smaller vessels. In addition, there are also other installations such as refineries and power generators that deal with oil.

The marine and coastal environment is endowed with natural resources (both living and non-living) that are of enormous economic significance to the nation in general, and to the welfare of coastal communities in particular. The transport of oil and petroleum products poses a major pollution threat to these valuable resources. Port activities such as the handling of petroleum tankers, in addition to the frequent tanker operations, present risks of oil spills. A combination of these scenarios therefore raises the prospect of chronic oil pollution with the potential of posing adverse (negative) impacts to the resources.

Kenya's environmental legislation, most of which established several decades ago, has been spread amongst about 77 legal statutes. Despite this volume of legislation governing an array of environmental issues, there was no explicit reference to the word "environment" in the constitution of 1977 [1]. Furthermore, the laws tended to be biased more toward the terrestrial environment, virtually ignoring the marine environment. The coordination and implementation of the laws have been difficult due to their sectoral nature. The enactment of the Environmental Management and Coordination Act (EMCA, 1999), passed in January 2000, has represented a significant step forward in dealing with environmental issues in general. This is an umbrella law established to achieve the harmonization and implementation of the environmental management laws [1,2]. In addition to national legislation, Kenya is signatory to a number of important regional and international environmental treaties and conventions.

The evaluation of the concept of effectiveness in the field of environmental policy involves addressing a number of central issues. First and foremost is the issue of institutional effectiveness. A regime/policy that operates in some sort of agreed-upon fashion is referred to as an effective institution. Secondly, there is the issue of impact (ecological or environmental) effectiveness. An impact effect is defined as any effect that influences the state of the policy issue (e.g., state of the environment) [3]. Kenya has the right policies and regulations in place to deal with the management of oil pollution (institutional effectiveness). However, this alone does not guarantee eventual effectiveness of the regulatory regime. The universally applicable methodologies for evaluation of the effectiveness of environmental policy involve establishment of a number of useful criteria and indicators [3]. The evaluation could thus be accomplished via analysis of instruments and appropriate indicators of the state of marine environmental health with respect to oil pollution.

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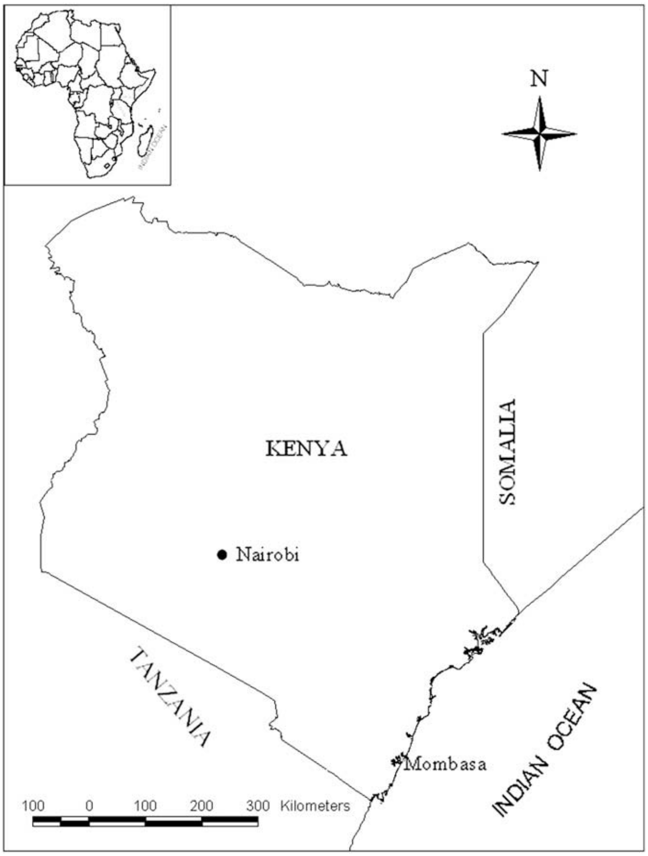

Fig. 1. Map of Kenya showing the Indian Ocean coastline.

2. The Kenyan coastline and the potential risk of oil pollution

The Mombasa port handles over 9 million metric tonnes of goods annually [4]. Tankers that berth at this port deliver approximately 2 million tonnes of crude oil to the Kenya Petroleum Refinery annually, and 109,000 tonnes of other oil products [1]. In April 2005, an Indian registered oil tanker accidentally hit the guardrails during routine docking at the port. In the process, one of the tanks got ruptured, spilling about 150 tonnes of oil into the open sea. This affected the fishing grounds for prawns and finfish, and the adjacent mangrove system.

Oil pollution is a major threat to the marine and coastal environment, as it produces a variety of deleterious effects across a wide range of habitats and species. Oil possesses a multi-pronged lethality, being a complex mixture of many hydrocarbon compounds with varying physical and chemical properties such as water-solubility, toxicity, and environmental persistence. The toxicological effects of petroleum hydrocarbons are therefore of direct, indirect, acute (short-term) and chronic (long-term) nature. The volatile low molecular weight, water-soluble fractions such as the smaller ring (1- and 2- ring) aromatic hydrocarbons are always associated with acute types of toxicity, e.g., narcosis. However, the high molecular weight components (3-, 4-, and 5-ring polycyclic aromatic hydrocarbons, PAHs) are toxic and very persistent in the environment. PAHs have been shown to produce toxic effects in a variety of marine fauna exposed to very low levels in field studies. Due to their hydrophobic nature (water-insolubility), PAHs tend to associate with particulate material and finally accumulate in the sediment. They have a high propensity to bio-accumulate in the marine food web, and therefore pose serious, long-term direct and indirect effects to a wide variety of marine biota, including valuable flora such as mangroves and seagrasses [5–8].

3. The marine and coastal resources and their susceptibility to oil pollution

The marine and coastal resources of enormous ecological and socio-economic importance include mangrove communities, coral reefs, seagrass communities, fisheries, and sandy substrates. They exhibit varying degrees of vulnerability and sensitivity to the negative effects of oil pollution, with the attendant potential to jeopardize the benefits derived from them. The vulnerability of each resource to oil pollution is described and assessed in the following sections.

3.1. Mangrove communities

Mangrove forests along the Kenyan coast cover an area of approximately 53,000 ha [9]. They are highly productive and biologically diverse, providing a sanctuary to a variety of terrestrial fauna [1]. The coastal communities use mangroves on a small scale for local needs such as fuel wood, fences, house construction, boat building, fish traps, and traditional medicine. Commercially, mangroves are an important item of trade and a source of employment and income. The mangroves also serve as a marvelous natural laboratory for scientific research through their unusual flora and fauna [10–12].

Mangrove habitats are highly susceptible to exposure to oil pollution by virtue of their existence at the interface between land and sea. Because they still water and trap sediments they are one of the principal places where spilled oil and associated impacts converge. They suffer both lethal and sub-lethal effects from oil exposure, the former having a long-term negative effect on mangrove communities independent of any persistent toxic effects of hydrocarbons on the organisms themselves [13]. More subtle responses include branching of pneumatophores, germination failure, decreased canopy cover, increased rate of mutation, and increased sensitivity to other stresses [14,15]. Greatest seedling mortality and lowest growth rate have been observed under hot, bright outdoor conditions [16]. The potential negative effects of oil on mangrove populations in Kenya, with temperatures varying between 25 °C and 31 °C throughout the year [1], may be exacerbated by the warm conditions.

3.2. Coral reefs

Coral reefs along the Kenyan coast are of the fringing variety composed of the reef slopes, coral flats, lagoons and reef platforms, covering an area of approximately 50,000 ha [9]. Most of the information on the status of coral reefs along Kenya's coastline is based on the marine protected areas (MPAs), the system of which is considered one of the best in the Western Indian Ocean region. The MPAs act as reservoirs of biodiversity, which include a variety of faunal and floral species, and coral reefs [17].

Coral reefs have not been shown to be highly sensitive to pollution from oil slicks, but the use of dispersants and other chemical agents in oil spill response activities has been shown to be detrimental to the health of the reefs. It has been estimated that 40% of the total oil spilled into the world oceans discharges into the Indian Ocean basin [17], and this puts the coral reefs along the Kenyan coast to a potential risk from the effects of chronic oil pollution. Results of studies of a Caribbean coral reef revealed that the effects of chronic oil pollution (discharges, small spills, clean-ups, etc.) were clearly discernible after a period of 60 years [18].

3.3. Seagrass communities

The Kenyan coast has an extensive coverage of seagrasses, occurring mostly in back-reef lagoons found between the beaches or cliffs and sheltered adjacent fringing reefs [1,19]. Seagrass ecosystems, like mangrove forests and coral reefs, are subject to many threats, both natural and anthropogenic. Living on the coastal fringe, seagrasses are under threat from oil pollution from a diverse range of sources [10].

Oil pollution is one of the potential threats to the seagrasses in Kenya owing to the large fleet of oil tankers that traverse the coastal waters daily, and the chronic release of oils in harbours, and in case of accidental spillages [1,19]. It has been observed that in most cases, oil has minimal direct effect on seagrasses in form of acute toxicity since they are mostly submerged plant communities. However, use of dispersants in treatment of oil spills, and enhanced irradiation from sunlight as is common in tropical environments, have been found to worsen the negative effects of oil on seagrasses [20,21].

3.4. Fisheries

Marine fisheries in Kenya account for only about 5% of the volume of fish landings, the large majority being from freshwater fisheries (inland lakes and rivers), predominantly from Lake Victoria. Despite the minimal contribution to the overall fisheries catch, a good proportion of the human population in coastal communities depends on marine fisheries for food security, employment and socio-economic stability [4].

Marine and coastal fishery resources worldwide, like coral reefs and mangroves, are under threat from a variety of both natural and anthropogenic factors. Exposure to petroleum and its components can potentially damage fishery resources in numerous ways, including reducing the reproductive rates of fish stocks. The effects observed include alterations in levels of reproductive hormones, inhibited gonodal development, and reduced egg and larval viability. It has been shown that chronic exposure of female Atlantic croaker to water-soluble fractions (WSF) of diesel fuel oil and naphthalene resulted in the blocking of sexual maturation in some fish and impaired ovarian recrudescence in others [22]. Field studies following the Exxon Valdez oil spill (EVOS), which occurred in Prince William Sound, Alaska, United States of America in 1989, reported oil-related declines in reproductive parameters in a number of marine teleost species due to chronic exposure to the pollutant. Fish collected from oil-impacted areas had high concentrations of metabolites of naphthalene and phenanthrene in bile, PAHs associated with some degree of carcinogenicity [23].

3.5. Sandy substrates

Along the Kenyan coast, sandy subtidal habitats dominate a good portion of the shoreline, influenced by two major rivers Tana and Sabaki, from Malindi to Lamu in the north. The soft bottom communities support significant shrimp and bottom fish populations which are the target of an active trawling industry [1]. Sandy intertidal, subtidal habitats and beaches along the coasts are important for biodiversity conservation since they support large meiofauna and other benthic communities. In addition to their contribution to biodiversity, sandy beaches are critical for tourism development due to their exceptional aesthetic value [24].

Despite the important functions associated with the sandy beaches and intertidal/subtidal habitats, they are quite vulnerable to oil pollution. Routine discharges from tankers carrying oil can contribute to chronic levels of oil pollution, occasionally severe enough to form tar balls and other residues on beaches and other areas. Significant spills can also become entrained in sediments, poisoning benthic life and, by extension, other marine wildlife that forage for food in sandy substrates. Littering of sandy beaches with tar balls is aesthetically distasteful to tourism [5,8,25]. Tar ball pollution has been observed on some tourist beaches in Kenya [25].

4. Legislation and regulations on the management of oil pollution

Kenya has the necessary legislation, both national and regional/international, for coastal and ocean management.

4.1. National legislation

Regulations on environmental pollution and its control are spread across a number of Acts, with different enforcing agencies. However, with regard to oil pollution, the Merchant Shipping Act (Cap 389 of the Laws of Kenya) is the principal statute that provides for the control of pollution of the sea by oil from ships. The Act is implemented by the Ministry of Transport in conjunction with other ministries, and is considered as the mechanism for regulating the pollution of Kenya's territorial waters arising from ship-based sources. Section 309 thus provides for the prohibition of pollution by oil from ships, originating from beyond the territorial waters. The Kenya Ports Authority (KPA), under the KPA Act (Cap 391 of the Laws of Kenya), has among other mandates, the responsibility for controlling oil pollution within the port and in Kenya's territorial waters.

Another statute which has a provision for the protection of pollution of Kenyan waters is the Fisheries Act (Cap 378 of the Laws of Kenya). The Act does not refer directly to the prevention of the aquatic environment from oil pollution, but Part X provides for the prevention of pollution and preservation and conservation of the fishery waters. The marine fishery waters are defined in the Act as the waters of the maritime zones described in the Maritime Zones Act (Cap 371 of the Laws of Kenya). Thus section 59 declares the Kenya fishery waters a pollution prevention zone for the purposes of protecting the aquatic environment and ecology.

In fulfillment of the responsibility vested upon it by the Act, the KPA, together with other stakeholders, has set up the National Oil Spill Response Committee (NOSRC). The committee has in turn developed a National Oil Spill Response Contingency Plan (NOSRCP) for dealing with oil spill incidents in Kenyan coastal waters and to oversee oil spill surveillance activities. Membership of NOSRC is drawn from private companies and parastatals involved in oil refining and distribution (the refinery and oil industries such as Esso Kenya Limited, etc.); government agencies dealing with maritime activities (the shipping industry), wildlife (Kenya Wildlife Service), resource and environmental conservation (Fisheries Department and Kenya Marine and Fisheries Research Institute). The primary objective of the contingency plan is to outline the procedures to be followed in combating and controlling oil spills in the territorial waters of Kenya.

The Environmental Management and Coordination Act (EMCA) of 1999 is the most comprehensive, providing for the management, protection and conservation of the environment in general. For administrative purposes under this Act, the National Environment Council (NEC) has been established (Part III, section 4). The functions of the council, as specified in Section 5, include policy formulation and direction; setting national goals and objectives and determining policies and priorities for the protection of the environment; and promotion of cooperation among public departments, local authorities, the private sector, non-governmental organisations and other organisations engaged in environmental protection.

Established under the Act (Part III, section 7) is the National Environment Management Authority (NEMA), the purpose of which is to exercise general supervision and coordination of all matters relating to the environment, and to be the principal instrument of Government in the implementation of all policies relating to the environment. Thus the functions of the Authority as outlined in section 9 include, among others, advising the Government on regional and international environmental conventions, treaties and agreements to which Kenya should be party, and following up the implementation of such agreements. Part XI (section 124) is devoted solely to international treaties, conventions and agreements [26].

4.2. Regional and international legislation

Kenya is signatory to a number of regional and international environmental treaties and conventions. The country is a contracting party to the Nairobi Convention, an international convention covering Eastern Africa and the Western Indian Ocean. This is an umbrella agreement that deals with the protection and management of the marine and coastal environment, and is implemented through the Regional Coordinating Unit (RCU) in the Seychelles, and the Department for Environmental Conventions (DEC) at UNEP headquarters in Nairobi [1]. The convention lists, among the pollution sources that require control, pollution from ships, and also has a protocol concerning cooperation in combating marine pollution in cases of emergency in the East African region.

The environmental provisions of the United Nations Convention on the Law of the Sea (UNCLOS) cover vessel-source pollution, among others (Kenya ratified the Convention on 2nd March, 1989). Articles 194(3)(b), 211, 217–221 outline the general framework of international norms concerning pollution of the marine environment by various forms of oil, including accidental pollution and dealing with emergencies. Article 211 is entirely concerned with pollution from vessels. It reaffirms the legislative objective and obligation of states to prevent, reduce and control pollution of the marine environment [27].

The various provisions of UNCLOS relating to jurisdiction over vessel violations of environmental norms have been supplemented by a global convention and by several conventions concerning regional seas. The general convention, the International Convention for the Prevention of Pollution by Ships (MARPOL 73/78) has as its objective "the complete elimination of intentional pollution of the marine environment by oil and other harmful substances and the minimisation of accidental discharge of such substances." The principal obligation of states parties to MARPOL Convention, contained in article 1, is to give effect to its provisions and its annexes. There are also regional seas conventions drafted under the auspices of UNEP. The conventions generally declare that the states parties shall take all appropriate measures conforming to international law to prevent, abate, combat and control pollution caused by ships and ensure effective implementation for the zones in question of applicable international rules relating to vessel-source pollution [27].

5. Evaluation of effectiveness of oil pollution management policies/regulations

There are some central issues relating to effectiveness evaluation in the field of environmental policy. The concept of effectiveness thus takes a central position in such evaluation. The dominant issue in the evaluation is institutional effectiveness, which implies that the regime/policy works as expected. Thus, as far as environmental policy is concerned, 'institutional effectiveness' refers to the extent to which output (tangible results, e.g., the number of environmental permits issued) of the policy matches the policy objectives. However, these output effects are the ones that are often monitored, and yet they rarely provide a direct indication of the policy performance (e.g., state of the environment). Closely related to institutional effectiveness is the issue of 'impact (ecological or environmental) effectiveness'. An impact effect is defined as any effect that influences the state of the policy issue (e.g., state of the environment, or the 'ultimate outcome') [3].

Evaluation of effectiveness of environmental policy is quite a challenge, as institutional effectiveness is not to be mistaken for policy effectiveness. The bottom-line effectiveness evaluation is impact effectiveness, which has a direct relationship with the policy performance, and ultimately needs an indicator set to provide an answer to the basic question: does the policy work? Environmental policy evaluations are therefore often linked to the use of a specific set of instruments and appropriate indicators of the state of the environment, such that an effectiveness evaluation is then an evaluation of those instruments in the policy context in which they are used [3]. Instruments can be defined as the resources that can be used by or through the government to attain policy objectives, and is accompanied by other components such as staff, administrative structures, financial means, training, and awareness raising. In other words, the resources dedicated to the design and implementation of a measure [3].

In oil pollution monitoring and evaluation of policy effectiveness, a number of indicators are being used worldwide. The most commonly used include beached bird surveys, tar ball monitoring, aerial surveillance and satellite remote sensing.

5.1. Beached bird surveys

Systematic surveys of beached oiled birds are considered as a powerful and highly sensitive indicator for marine oil pollution, as the mortality of seabirds is one of the most obvious adverse effects of pollution of the world oceans with oil. The indicator has been used in many parts of the world to document the effect of oil pollution, particularly in parts of North America and Western Europe. It is a cost-effective method that can be used to detect trends in chronic oil pollution, and to evaluate changes in policy [28].

An increase in the penalties for polluting of coastal waters has been associated with a marked reduction in oiled bird encounter rates on Polish beaches. Conversely, a concerted multi-agency effort to combat illegal discharges of oil off Newfoundland off the east coast of Canada coincided with an increase in oiled bird encounter rates [28]. Beached bird surveys on the Central California coast reportedly contributed to the discovery, identification and prosecution of sources of pollution [29]. The indicator therefore provides a powerful tool for assessing the effectiveness of measures for the reduction of oil pollution, and the protection of marine/coastal environment from the adverse effects of oil pollution. However, the indicator has not been used in Kenya.

5.2. Tar ball monitoring

Quantitative measurement of beach tar has been used as an indicator of chronic petroleum pollution of the oceans from a variety of sources. Systematic beach surveys of stranded tar balls may also be used for the identification of oil pollution trends. The chemical characterisation of the components of the petroleum residues can be used to identify the sources of pollution, and this could contribute to the effectiveness of regulation and prosecutions [30,31]. The long-term and systematic monitoring of ocean-facing beaches for tar ball distribution furnish us with a simple and inexpensive way of verifying changes in pollution input from shipping and other port/coastal activities, and the effectiveness of national/regional oil pollution control policies and international laws such as MARPOL 73/78 [30,31]. Earlier surveys along the tourist beaches on the Kenyan coast have shown evidence of tar ball pollution [25,32]. However, no systematic surveys have been in place on a continuous basis.

5.3. Aerial surveillance

Aerial surveillance of oil spills from vessels and platforms is conducted by a number of countries for the purpose of deterring illegal operational discharges and to evaluate marine pollution. It is therefore a valuable indicator of the state of pollution of the marine environment, and the effectiveness of pollution control measures.

The monitoring approach is widely used over the North Sea, Baltic Sea, and the Mediterranean Sea (International Maritime Organisation "special areas"). In these areas, illegal discharges of oil from maritime transport, off-shore installations, and refineries (both off-shore and shore-sited) – the three main sources of oil pollution into the marine environment – are prohibited. Monitoring of oil spills by aerial surveillance can thus partially serve as an aid to detecting and combating pollution, and to detect and prevent violations of anti-pollution regulations [33]. However, this approach is not applied in Kenya on a routine basis due to the high cost implications.

5.4. Satellite remote sensing

Operational satellite surveillance services are being used by a number of pollution control agencies around the world in an effort to control chronic oil pollution through detection and apprehension. Space-borne remote sensing has thus proved to be an important tool in monitoring marine oil spills due to its wide spectral coverage, insensitivity to weather and regular revisit capability. It has been shown that ship observations and aircraft surveillance have proved useful, but they are of limited coverage and high operational cost. Therefore, pollution control authorities in various countries have resorted to satellite remote sensing for their oil spill detection systems [34]. Some of the countries currently using satellite surveillance operationally for oil pollution management include Norway, the United Kingdom, the United States of America, Canada, Singapore (covering a large part of the Southeast Asian coastal waters), and Denmark. Detection of oil discharges using satellite technology thus offers the most promising method for monitoring spills, and hence a good deterrent to illegal discharges of oil at sea. However, like aerial surveillance, the applicability of this approach is a major challenge to Kenya owing to the attendant intricacies and high cost implications.

6. Conclusion

Kenya has the necessary legislation in place for coastal and ocean management, with the enactment of EMCA, 1999, and being a signatory to a number of regional and international environmental treaties and conventions. However, effectiveness of environmental policy is not to be mistaken for institutional effectiveness, as the bottom-line in such an evaluation is impact effectiveness. In an area such as the management of marine oil pollution, such an evaluation can in part be accomplished via analysis of a set of instruments and appropriate indicators of marine environmental health. There are no monitoring programmes (indicators) in place in Kenya. Thus in addition to the analysis of institutional capacity, i.e., the attributes that make for an effective and sustainable institution, the presence of appropriate indicators with which to gauge the effectiveness of the regulatory regime is necessary.

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References

[1] Obura D. Kenya. Marine Pollution Bulletin 2001;42(12):1264–78.
[2] Mutiso JW. Integrated waste management and marine pollution in Kenya. Country report presented at the international maritime organisation Southern/East African networking workshop, Cape Town, South Africa; 2001. p. 37–40.
[3] Gysen J, Bachus K, Bruyninckx H. Evaluating the effectiveness of environmental policy: an analysis of conceptual and methodological issues. Paper presented at the European evaluation society Seville conference, Seville, Spain; October 10–12, 2002. p. 17.
[4] Government of Kenya. National assessment report for the world summit on sustainable development (RIO + 10). Johannesburg, South Africa: GOK; 2002. p. 54+.
[5] Da Silva EM, Campos PM, Teixeria NM, Azevedo CC. Impact of petroleum pollution on aquatic coastal ecosystems in Brazil. Environmental Toxicology and Chemistry 1997;16(1):112–8.
[6] Trust KA, Elser D, Woodin BR, Stegeman JJ. Cytochrome P450 1A induction in sea ducks inhabiting nearshore areas of Prince Edward sound, Alaska. Marine Pollution Bulletin 2000;40(5):397–403.
[7] Peterson CH, editor. The "Exxon Valdez" oil spill in Alaska: acute, indirect and chronic effects on the ecosystem. Advances in Marine Biology 2001;39:1–103.
[8] Tolosa M, de Mora S, Sheikholeslami MZ, Villeneuve J-P, Bartocci J, Cattini C. Aliphatic and aromatic hydrocarbons in coastal Caspian Sea sediments. Marine Pollution Bulletin 2004;48(1–2):44–60.
[9] Eastern African atlas of coastal resources: Kenya. UNEP/Belgian administration for development cooperation. Nairobi, Kenya: UNEP; 1998. p. 119.
[10] Hatcher BG, Johannes RE, Robertson AI. Review of research relevant to the conservation of shallow tropical marine ecosystems. Oceanography and Marine Biology: An Annul Review 1989;27:337–414.
[11] Duke NC, Watkinson AJ. Chlorophyll-deficient propagules of Avicennia marina and apparent longer term deterioration of mangrove fitness in oil-polluted sediments. Marine Pollution Bulletin 2002;44:1269–76.
[12] Semesi AK, Howell K. The mangroves of the Eastern African region. UNEP; 1992. p. 45.
[13] Garrity SD, Levings SC, Burns KA. The Galeta oil spill: I. Long-term effects on the physical structure of the mangrove fringe. Estuarine, Coastal and Shelf Science 1994;38:327–48.
[14] Dutrieux E, Martin F, Debry A. Growth and mortality of *Sonneratia caseolaris* planted on an experimentally oil-polluted soil. Marine Pollution Bulletin 1990;21(2):62–8.
[15] Klekowski Jr EJ, Corredor JE, Morell JM, Castillo CA. Petroleum pollution and mutation in mangroves. Marine Pollution Bulletin 1994;28(3):166–9.
[16] Proffitt CE, Devlin DJ, Lindsey M. Effects of oil on mangrove seedlings grown under different environmental conditions. Marine Pollution Bulletin 1995;30(12):788–93.
[17] Salm RV. The status of coral reefs in the Western Indian Ocean. Working paper prepared for the international coral reef initiative (ICRI) workshop, Seychelles; 1996.
[18] Bak RPM. Effects of chronic oil pollution on a Caribbean coral reef. Marine Pollution Bulletin 1987;18(10):534–9.
[19] Ochieng CA, Erftemeijer PLA. The seagrasses of Kenya and Tanzania. In: Green EP, Short FT, editors. World atlas of seagrasses (UNEP-WCMC). The University of California Press; 2003. p. 82–92.
[20] Durako MJ, Kenworthy WJ, Fatemi SMR, Valavi H, Thayer GW. Assessment of the toxicity of Kuwait crude oil on the photosynthesis and respiration of seagrasses of the northern Gulf. Marine Pollution Bulletin 1993;27:223–7.
[21] Macinnis-Ng Catriona MO, Ralph PJ. In situ impact of petrochemicals on the photosynthesis of the seagrass *Zostera capricorni*. Marine Pollution Bulletin 2003;46:1395–407.
[22] Thomas P, Bundiantara L. Reproductive life history stages sensitive to oil and naphthalene in Atlantic croaker. Marine Environmental Research 1995;39:147–50.
[23] Sol SY, Johnson LL, Horness BH, Collier TK. Relationship between oil exposure and reproductive parameters in fish collected following the Exxon Valdez oil spill. Marine Pollution Bulletin 2000;40(12):1139–47.
[24] Ansari ZA, Ingole B. Effect of an oil spill from MV Sea transporter on intertidal meiofauna at Goa, India. Marine Pollution Bulletin 2002;44:396–402.
[25] UNEP. Marine pollution in the East African region. FAO/UNEP regional seas reports and studies no. 8; 1982. p. 54.
[26] Environmental Management and Coordination Act no. 8. EMCA. Nairobi, Kenya: Government Printer; 1999. p. 81.
[27] Kiss A, Shelton D. International environmental law. Ardsley-on-Hudson, Newyork: Transnational Publishers Inc.; 1991. p. 168–78.
[28] Wiese FK, Ryan PC. Trends of chronic oil pollution in southeast Newfoundland assessed through beached-bird surveys 1984–1997. Bird Trends 1999;7:36–40.
[29] Roletto J, Mortenson J, Harrald I, Hall J, Grella L. Beached bird surveys and chronic oil pollution in Central California. Marine Ornithology 2003;31:21–8.
[30] Butler JN, Wells PG, Johnson S, Manock JJ. Beach tar on Bermuda: recent observations and implications for global monitoring. Marine Pollution Bulletin 1998;36(6):458–63.
[31] Zakaria MP, Okuda T, Takada H. Polycyclic aromatic hydrocarbons (PAHs) and hopanes in stranded tar-balls on the coasts of Peninsular Malaysia: applications of biomarkers for identifying sources of oil pollution. Marine Pollution Bulletin 2001;42(12):1357–66.
[32] Nguta CM. Tar ball monitoring along the Kenyan coastline. Second WIOMSA scientific symposium, book of abstracts; 2001. p. 70.
[33] Volcaert FAM, Kayens G, Schallier R, Jacques TG. Aerial surveillance of operational oil pollution in Belgium's maritime zone of interest. Marine Pollution Bulletin 2000;40(11):1051–6.
[34] Espedal HA, Johannessen OM. Detection of oil spills near offshore installations using synthetic aperture radar (SAR). International Journal of Remote Sensing 2000;21(11):2141–4.