Effects of Environmental Oil Spills on Commercial Fish and Shellfish in Suez Canal and Suez Gulf Regions (Review Article)

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Abstract: Oil pollution is a major environmental problem and is important, in particular to the Suez Canal and Suez Gulf as the main routes of many oil tankers. In view of the increased incidents of oil spills, it was necessary to discuss the impact of oil spills on the fishery community. In this review, the following approaches will be attributed: a) the morphological, biochemical and pathological reactions of marine fish and shellfish to oil pollution. b) The impact of oil toxicity in spawning and reproduction of shellfish and migratory fish. c)the bacterial solving crude oil. d) The expected effects of that pollution on human health. This project includes: analysis of water quality (chemical, physical, etc), detection of oil pollutants residues in water, fish and shellfish, and parasitic diseases affecting fish, studying of the pathological and clinico-pathological affections of such fishes, and the impact of oil pollution on fish resources and trials of prevention and control of such pollution.

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1. Introduction:

In recent years, oil pollution has become a global environmental issue in that oceanic ecosystems and inland aquatic breeding ecosystems are threatened greatly. The evaluation and prediction of the effects of oil pollution on water environment have become a very urgent and important issue. It has been estimated that approximately 5 million tons of crude oil enters the marine environment each year from deferent of sources **(Neff, 1990; Kennedy and Farrell, 2008)**. Mostly known are the spills from shipwreck, but there are several more less conspicuous sources, like intentional flushing of ship compartments, spills from oil rigs, oil from industries, oil refineries, run-off from urban areas. More than 200 ship accidents were occurred during the period 1990–2001 and some of those resulted in major spills into the marine environment. For example, in March 1994, a tanker collided with another ship and 20000 tons of oil were spilled into the strait waters (Marmara Sea, Turkey) and affected many organisms and caused mass mortality of some species **(Öztürk *et al.*, 2001, Karacik *et al.*, 2009)**.

Egypt, with its long and sensitive coastline which is situated in the centre of the marine transpiration lanes of oil from east to west, has had a possibility in some spills. The Suez Canal alone is crossed by some 20,000 vessels, annually, that carry about 14% of the world's trade. This includes 2,500 tankers. The average amount of crude oil originating mainly from the Gulf, but also from local production, passing daily the Suez Canal is approximately 800,000 barrels. The Suez Canal has been deepened recently to the depth of 17.5 m, which makes it navigable for all but the largest oil tankers. Pollution generated by shipping, notably oil tankers, particularly along the shipping lines leading to and from the Suez Canal contaminates both sea and beaches. It is partly caused by emptying and washing ships' bilges and oil and fuel tanks at sea, and partly by waste and litter, some of it of practically indestructible plastic materials, jettisoned by ships. The crude-oil load on the Suez Canal environment is also due to the local production centering predominantly on the Gulf of Suez basin. Annual oil production now exceeds 15 million tons and takes place over an area of 8,000 sq km. Regretfully oil pollution incidents are the routine consequences of normal operating procedures. Oil tankers and other ships constitute another significant source of oil pollution and the southern entrance to the Gulf is presently used as a waiting-area for ships before they enter the canal. These two chronic sources of pollution constitute a considerable hazard to the local fisheries. Oil pollution affects both the physical properties of the water and the biological life within it. Oil on the water surface reduces the exchange of gases contributing to reduced levels of dissolved oxygen, and promotes the absorption of solar energy that increases water temperature and reduces the solubility of oxygen. Some of the components of oil are soluble in water, such as phenyls, and are directly toxic to marine life. These chemicals may cause physiological damage to fish and lead to premature mortality. Even at low concentrations the fish may absorb hydrocarbons from the water so that the meat becomes 'tainted' and unfit for human consumption. The major impacts of oil pollution on fisheries and aquaculture are the smearing of nets and fish cages and the tainting of fish and shellfish, rending them unfit for marketing. As compared to adult, which can avoid contaminated areas, the early developmental stages such as eggs, larvae and juvenile fish, to oil in surface waters, is at higher risk **(Barrick *et al.*, 1985; Quigley *et al.*, 1996)**.

It is difficult to examine biodegradation kinetics and relative rates without basic knowledge of the various microbial species and specific environmental conditions. The rate of biodegradation depends on both physico-chemical and biological variables. **Churchill *et al.* (1995)** coined the term ''bioavailability of hydrophobic organic compounds'', which is a function of phase-solubility and solution-transport processes. The ability of hydrophobic organic compounds to be solubilized and transported into the immediate vicinity of bacterial cells capable of metabolizing them is potentially the rate-limiting step in bioremediation. Degradation of hydrocarbons in the presence of synthetic surfactants is a delicate issue

It is well known that oil spills can result in significant polycyclic aromatic hydrocarbons (PAHs) contamination of local fish and shellfish, depending on the volume of the spill, the type of oil spilled and the exposure of the fish and shellfish to spilled oil **(Kelly *et al*., 2008)**. PAHs have been known to affect a variety of biological processes and may exhibit a wide range of hazardous effects to aquatic organisms including acute toxicity, developmental and reproductive toxicity, photo-induced toxicity, and can be potent cell mutagens and carcinogens **(Gaspare *et al.*, 2009, Karacik *et al.*, 2009)**, in addition to well-documented sublethal effects which include morphological and histopathological damage **(Brown *et al.*, 1996; Carls *et al.*, 1999; Heintz *et al.*, 1999)**, physiological and stress effects, endocrine disruption **(Kennedy and Farrell, 2006)**, and ecological effects **(Reddy *et al.*, 2002)**. Sediment-associated PAHs are known to exhibit narcotic effects in benthic organisms **(Di Toro and McGrath, 2000)** but also have been implicated in the development of tumors in bottom feeding fish **(Myers *et al.*, 1991; Balch *et al.*, 1995)** and in the induction malformation, loss of fertility or immune deficiency in aquatic vertebrates **(Reynaud *et al.*, 2004)** and invertebrates **(Gagnaire *et al.*, 2006)** including oysters **(Jeong and Cho, 2005)**. Due to their lipophilicity, PAHs are known to accumulate in sediments as well as in fish and shell fish especially in mussels and other aquatic invertebrates **(Gewurtz *et al.*, 2000)**. By accumulating in invertebrates, PAHs also enter the aquatic food webs and also pose a risk to human health via consumption of seafood **(Okay *et al.*, 2003; Karacik *et al.*, 2009))**. It has been reported that consumption of shellfish polluted by PAHs may cause lung cancer in humans **(Law and Klungsoyr, 2000; Gaspare *et al.*, 2009)**.

The risk of an oil spill is high since an estimated 100 million tons of oil and oil products are transported annually through the region by 20,000 - 35,000 tankers. Furthermore, the risk of vessel collision is enhanced by insufficient navigational aid and unregulated maritime traffic **(Persga, 1998)**.

It is known that wastewater discharged from the petroleum industry may contain a wide range of organic and metallic pollutants, including phenols, oil and grease, sulfides, ammonia nitrogen, and polycyclic aromatic hydrocarbons (PAHs) **(Dasgupta and Zdunek, 1992)**. Some of these are used or produced during the process of refining, but many are contained in the crude oil itself **(Porte and Albaiges, 1993)**. Some of these contaminants, such as PAHs, are known to be carcinogenic while others are known to be oxidant **(Paglia and Valentine, 1967)**.

Among the different types of pollutants, petroleum products are one of the most relevant to aquatic ecotoxicology **(Pacheco and Santos, 2001a)**. Exposure to crude oil and derivatives can induce a variety of toxic symptoms in experimental animals. Petroleum hydrocarbons can act as a mediator in free radical generation in fish **(Achuba and Osakwe, 2003)**. Studies with the goldfish *Carassius auratus* has shown an increase in antioxidant defenses in animals after exposure to different concentrations of the water-soluble fraction of diesel oil (WSD) for various experimental times **(Zang *et al*., 2003 and 2004)**. Other studies have also indicated that the exposure of fish to a water-soluble fraction of petroleum derivatives causes different effects in cortisol plasma concentrations **(Alkindi *et al*., 1996; Pacheco and Santos, 2001a, b)**, suggesting that these contaminants might interfere in the fish stress response. Some authors have shown a relationship between exposure to petroleum hydrocarbons and hemolysis and/ or hemorrhage **(Alkindi *et al*., 1996)**, while others have observed an increase in hematocrit of fish exposed to a WSD **(Davison *et al*., 1992)**. Some works have also shown structural damage to organs and tissues related to the exposure of fish to petroleum derivatives**.** On the other hand, different results were reported for the Antarctic fish *Pagothenia borchgrevinki* which showed an increase in hematocrit and hemoglobin content after acute exposure to a WSD **(Davison *et al.*, 1992)**. Thus, it is clear that exposure to the same chemical agent can induce different alterations (increase or decrease) in hematological parameters **(Ranzani-Paiva and Silva-Souza, 2004)**, which can indicate adaptive responses to a stress agent or the direct effects of these contaminants on erythrocytes or their production. In flounder (*Pleuronectes flesus*) exposed to a water-soluble fraction of crude oil for 3, 24, and 48 hrs. **Alkindi *et al.* (1996)** demonstrated an increase in plasma cortisol concentration. Dose-dependent increases in catalase activity in the liver and other organs were found after 14, 21, and 28 days in African catfish (*Clarias gariepinus*) exposed to crude oil **(Achuba and Osakwe, 2003)**. **Zang *et al.* (2003)** exposed goldfish (*Carassius auratus*) to different concentrations of diesel oil for 40 days and also found that catalase activity increased significantly at one of the concentrations tested. **Khan (1998)** also found in the gills of flounder (*Pleuronectes americanus*) collected near an oil refinery, hyperplasia in the lamellae and in the inter-lamellar space, as well as epithelial lifting, and this author suggested that the lesions found were related to the oil spills. In another study with flounder collected at a location contaminated with PAHs, gills showed alterations such as hyperplasia and hypertrophy of the lamellar epithelium resulting in fusion and increase in mucus production **(Khan, 2003)**. Rainbow trout (*Onchorrynchis mykiss*) exposed to two types of oil components also showed gills with anomalies in the lamellar epithelium and drops of oil located between the lamellae and an influx of ions has been attributed to damage or changes in chloride cells **(Engelhardt *et al.*, 1981)**. Herring gills exposed to water soluble fractions of oil (WSF) concentrations exhibited epithelial hyperplasia and a minor epithelial lifting **(Kennedy and Farrell, 2005)**. Hydrocarbons are acting directly as an endocrine disruptor, targeting the pituitary or adrenocortical tissues **(Dorval *et al.*, 2003; Kennedy and Farrell, 2006)**. PAH exposure has previously been shown to affect steroidogenesis (testosterone) in rainbow trout tissue **(Evanson and Van Der Kraak, 2001)**. Defence mechanisms, which include wound repair, coagulation, nodule formation, encapsulation, phagocytosis and cytotoxicity **(Cheng, 1981)**, could be impaired by hydrocarbons **(Wootton *et al.*, 2003; McVeigh *et al.*, 2006)**. It is noteworthy that alterations in the homeostatic mechanisms, including the immune system are critical, since these predispose an animal to severe infection and subsequent disease **(Fournier *et al.*, 2000; Gopalakrishnan, *et al.*, 2009)**. After chronic exposure to petroleum hydrocarbons, the prevalence and intensity of parasitism increases substantially in fish **(Khan, 1990)**. A study in flounder (*Pleuronectes vetulus*) exposed to sediment contaminated with PAHs, also revealed the presence of severe hepatic lesions, besides metabolites of these compounds in bile **(Myers *et al.*, 1998)**. Flounder (*Pleuronectes americanus*) collected near an oil refinery also showed various histological lesions in the liver which were considered indicative of the impact of the oil on the health of these fish **(Khan, 1998, 2003)**.

Karacık *et al.* (2009) analyzed samples of surficial sediments and mussels (*Mytilus galloprovincialis*) from the Istanbul Strait (Marmara Sea, Turkey) for sixteen parent polycyclic aromatic hydrocarbons (PAHs) contents and observed that total PAHs concentrations ranged from 2.1 to 3152 ng g^{-1} dry wt in sediments and from 43–601 ng g^{-1} wet weight in mussels which showed both reduced lysosomal membrane stability and filtration rate indicating disturbed health. Benzo(a)pyrene was found to decrease significantly the total number of circulating haemocytes in abalone (*Haliotis diversicolor*) whereas phagocytic activity was decreased significantly at higher concentration (**Gopalakrishnan, *et al.*, 2009**). **Gagnaire *et al.* (2006)** observed that benzo[a]pyrene, phenanthrene and anthracene tested on Pacific oyster haemocytes induced a decrease in cell mortality after 24 hrs incubation. Both phagocytosis and lysosomal integrity were inhibited when the mussels (*M. edulis*) were exposed to environmentally realistic concentrations of the PAH mixture for 2–4 weeks **(Grundy *et al.*, 1996)**, illustrating the potential impact of PAH on lysosomal membrane damage **(Gagnaire *et al.*, 2006; McVeigh *et al.*, 2006)** in these animals which leads to alter the immune function in *M. edulis* (**Gopalakrishnan, *et al.*, 2009**). In a recent study, abnormalities during oyster larval development have been observed above critical body burdens of 300 ng PAHs/g dry weight in oyster larvae **(Geffard *et al.*, 2003; Gaspare *et al.*, 2009)**.

Crude oil was toxic for the cyanobacterial grazers but not for these photosynthetic organisms. This process was proposed to be a first step towards natural bioremediation **(Radwan *et al.*, 1999)** but partial oil elimination was also attributed to the combined effects of physico-chemical weathering and microbial degradation **(Sauer *et al.*, 1998).** Other reports indicated that cyanobacterial building mats in the Saudi coast led to preservation of oil residues **(Barth *et al.*, 2003).**

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