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A Review of What is Known about Impacts of Coastal Pollution on Childhood Disabilities and Adverse Pregnancy Outcomes

Juma Rahman^{1*} Nitaya Vajanapoom² Marc Van Der Putten³

1. Faculty of Public Health (Global Health), Thammasat University, PO box 12120, Pathum Thani, Thailand.
2. Assoc. Professor. Vice Dean for academic: Epidemiology. Faculty of Public Health. Thammasat University, PO box 12120, Pathum Thani, Thailand.
3. Asst. Professor. Asst. Dean International Affairs. Faculty of Public Health. Thammasat University, PO box 12120, Pathum Thani, Thailand.

* E-mail of the corresponding author: jumarahman@gmail.com

Abstract

Coastal pollution is getting global attention for its enormous impacts on human health by the means of consumptions of seafood, involvement of risky jobs and exposure to water related disastrous events. Critical review of published and unpublished literatures and documents show the effects of heavy metals, chemicals, and radioactive substances are considered as long termed and deadly, and children and pregnant women are the most vulnerable population to such exposures and at risk of adversely affecting their development. The physiological systems of children and fetuses are developing fast and usually sensitive to disruptions induced by environmental pollutants and exposures in utero increase the risk of future toxic insults. Almost sixty percent of the world's population is at risk of this contamination and coastal developing countries are facing significant challenges by this form of pollution. The main objective of this review was to explore the situation of coastal water pollution and its impact on child health and pregnancy outcomes globally. However, these observations are indecisive due to limitations of evidence to support. Therefore, further epidemiological studies are required to confirm these initial observations.

Keywords: Coastal pollution, heavy metal, radionucleotides, childhood disability, adverse pregnancy outcome.

1. Introduction

There are numerous connections between the oceans, human activities, and human health effects. These connections may turn into more intimate in negative senses by coastal pollution (Hauke, et al., 2008). The health and well being of the individuals and populations can be affected at different levels by anthropogenic and natural factors of coastal pollution including: harmful algal blooms, microbes, and chemical pollutants in the oceans; consumption of seafood; involvement of risky jobs and offshore flooding events. These effects of coastal pollution is drawing global attention due to its transboundary issues and threat to huge coastal community (globally population density in the coastal zone is 2.6 times greater than the inland) (Michel & Pandya, 2010). Almost sixty percent of the world's population, i.e. 3 billion people (lives on or within 100km of a sea coast) face huge health-related effects due to continuous changing coastal-configuration and pollution (Klein, Nicholls, & Thomalla, 2003).

Therefore, this review aims to examine evidences of coastal water pollutions, including heavy metals, chemicals and radioactive pollutions, and their impacts on child health and pregnancy outcomes in coastal countries. This review focuses on children and pregnant women because of their vulnerable physiological conditions to the impacts of environmental factors.

2. Background

The United Nation defines coastal pollution as the introduction by man, of substances or energy to the marine environment, directly or indirectly, resulting in deleterious effects such as: hazards to human health, hindrance to marine activities, impairment of the quality of seawater for various uses and reduction of facilities (Henry, n.d.). It was estimated that globally 10,000 million gallons of sewage, 3.25 million metric tons of oil, 10 billion tons of ballast water and millions of tons of solid waste are discharged into the marine environment per annum (Ruiz-Villarreal, et al., 2006; UNEP, 2006a). Furthermore, industrial untreated wastes are contributing to the “coastal dead zone” (i.e. insufficient oxygen level to support marine life) extension and heavy metal contamination to the sea food constantly. Almost 70% industrial discharges and 85% of waste water are discharged untreated from developing countries. For instance, annually more than 600,000 tonnes of nitrogen is delivered into the Indian Ocean, while 17 tonnes of mercury and nearly 150 tonnes of cadmium are discharged into the Caspian Sea (Hossain, 2006; UNEP, 2006b). Estimation shows tannery industries in Bangladesh (Chittagong) discharge nearly 150,000 litres of liquid waste per day while the Karnaphuly Paper Mill releases 0.35 tons of China clay everyday to the Bay of Bengal without minimal degree of treatment (ADB, 2009). Figure-1 shows the distribution across global regions of the ratio of treated and untreated wastewater reaching seas and oceans; where it is found that 80% to nearly 90% of sewage entering coastal waters to be raw and untreated, originate mostly from developing countries (UNEP, 2006a) including the countries of the Indian Ocean rim, East Africa, the Arabian Peninsula and South and Southeast Asia.

In addition to these land based pollutants ship-breaking yard, oil spill from vessels and off shore platforms are the significant sea based ocean pollutants. For instance in Indonesia almost every year, oil spill incidents occur in the Strait of Malacca and Riau Islands (Agustina, 2011). Nevertheless in Bangladesh, India and Pakistan heavy metal discharge and oil spill occur mainly from ship breaking industries, and fishing trawlers (MoEF, 2004). Like other offshore power-plants, tritium is routinely released from the reactor of Chennai power-plant, India into the Bay of Bengal which affects neighbouring countries deleteriously (Ramesh, Nammalwar, & Gowri, 2008).

Among a variety of pollutants, the effects of heavy metals, chemicals, persistent organic pollutants (POPs) and radioactive substances are considered as long termed and deadly (Hauke, et al., 2008) because of their genotoxic and carcinogenic outcomes. There are many studies supporting the poisonous effects by these pollutants. Lead, mercury, cadmium, arsenic, persistent organic pollutants, polycyclic aromatic hydrocarbons (PAHs) can be accumulated into soil, seafood, grains and sediments and thus get entry into the human food chain (Cao, et al., 2010; UNEP, 2006b). Table 1 shows the main grains of Bangladesh contain significant amount of heavy metals cultivated in the contaminated soil.

Again it was reported that sea food is the main source of mercury consumption in human beings (Elhamri, et al., 2007; Holsbeek, Das, & Joiris, 1996). Figure 2 shows a diagrammatic picture of the process of mercury accumulation in the food chain. Bacteria in the water cause chemical changes of mercury into methyl mercury that is easily absorbed by fishes. Thus sea foods are the main source of mercury exposure to humans.

All of them remain active for even thousands of years and affects human health adversely for long term (Brooks, 2010). The most harmful effect takes place when they pass to the future generation by chromosomal abnormalities and effects on child’s development (O’Hanlon, 2010). Thus these pollutants get an intimate connection with the global burden of diseases by increasing childhood disabilities (physical and neurological) and unexpected pregnancy outcomes.

2.1 Adverse Health Impacts of Heavy Metals and Chemical Pollutants on Child and Pregnant women

Heavy metal poisoning got attention at first in Japan in 1912, when cadmium was found as a causative agent of acquired Fanconi Syndrome. Researchers found that cadmium can cause renal tubular dysfunction (kidney failure) and osteomalacia (softening of bone) with severe pain in the bones. Hence the disease is called Itai-itai Byo (Japanese; Itai means pain) (Friberg, Piscator, Nordberg, & Kjellstrom, 1984; UNEP, 2006b). Again in 1956, Minamata disease was discovered at Minamata city in Kumamoto industrial

prefecture, Japan due to mercury poisoning in the downstream water. Manifestations of Minamata disease are- numbness of limbs, difficulties in moving hand and leg, tremor of hands, hearing difficulties, language disorder, visual field constriction, distortion of sense of equilibrium and finally people become insane leading to death. Later on a considerable number of children with conditions resembling cerebral palsy were born in the exposed areas of Japan (Harada, Yorifuji, & Tsuda, 2011).

Since then a large number of studies were conducted worldwide. Among them the 14 years of cohort study in the Faroese Island by Philippe Grandjean is worth to mention. In this cohort study, a cohort of 1022 singleton births was assembled in the Faroese Islands during a 21-month period of 1986–1987. Fifteen percent of the mothers had hair mercury concentrations above 10 mg/g, whereas cord blood concentrations ranged up to 350 mg/l. However, obvious cases of congenital methyl mercury poisoning were not found and expected to be appropriate at school age. So the children were invited again on 1993 and neurological tests were performed (Grandjean, et al., 1997). The results have shown that the prevalence of neurological impairments of children increased with the mercury concentration in maternal hair.

At the age of 14, the children were again examined and decreased cardiac activity was found. This cohort study demonstrated that prenatal exposure to mercury (Methyl mercury) by maternal consumption of contaminated sea food can lead to cognitive deficit in their children, with more pronounced manifestations in the domains of language, attention and memory and decreased cardiac activity in children (Grandjean, Murata, Budtz-Jørgensen, & Weihe, 2004; Grandjean, et al., 1997).

Furthermore, there are some studies that suggest similarities in the causal relation of Autistic Spectrum Disease with the mercury poisoning in children due to prenatal exposure. For instance children with autism had a 2-time higher level of mercury in their baby teeth and excrete 3.1 times higher mercury into their urine (Adams, et al., 2009).

Moreover mercury can cause higher risk of spontaneous abortion if paternal exposure is high. The results of studies indicated an increase in the rate of spontaneous abortions with an increasing concentration of mercury in the fathers' urines before pregnancy. Direct action of mercury on the paternal reproductive system and indirect toxicity to the mother or embryo through transport of mercury from the father was found as biological mechanism. It was found that mercury concentration in urines of fathers above 50 micrograms/l increased risk of spontaneous abortion (OR = 2.26; 95% confidence interval = 0.99-5.23) (Gerhard, Waibel, Daniel, & Runnebaum, 1998).

Other heavy metals like arsenic and lead also have adverse impacts on development of the brain in foetuses and pregnancy outcome besides adulthood diseases. Although arsenic is mostly a natural pollutant, there are many industrial effluents (e.g. from tanneries and ship breaking) that contain significant amount of arsenic and lead (Huq, 1998; Khan & Khan, 2003). In addition to ground water consumption arsenic can also be consumed by grains irrigated or cooked with contaminated water and even with sea food (e.g. shrimps and finfish) (Alam, Snow, & Tanaka, 2003; Khan, et al., 2011; Meliker, Wahl, Cameron, & Nriagu, 2007; Rahman, et al., 1999; Soleo, et al., 2008). Furthermore chronic lead exposure can cause cataract formation by preventing antioxidant reaction of the body (OR, 1.88; 95% CI, 0.88-4.02) (Cromie, 2004; Schaumberg & et, 2005).

However, recently lead exposure has been connected to ocular neuritis in children which may lead to visual impairment or complete loss of vision (Christophers, 1999). Researchers found that lead causes increased intracranial pressure which directly irritates the optic nerve, condition known as “ocular plumbism” believed to be due to swelling rather than inflammation. It has been suggested that the increased intracranial pressure induced by lead exposure can also cause paralysis of the external recti (straight) muscles involved in eye movement. This may contribute to strabismus (a condition in which the eyes do not point in the same direction), and consequently, double vision (Christophers, 1999; Gibson, 1931).

Lead, Manganese and Arsenic have a huge impact on pregnancy outcome as well like spontaneous abortion, still birth, low birth weight (LBW), prematurity and early neonatal death (Milton, et al., 2005; Rahman, et al., 2007). A cross-sectional community based study in Punjab shown spontaneous abortion and premature births were significantly higher in area affected by heavy metal and pesticide pollution ($p < 0.05$). Stillbirths

were also five times higher (Thakur JS, et al., 2009).

It was evident from literatures review that anthropogenic chemicals, particularly Persistent Organic Pollutants are associated with possible increased risks reproductive disorders as well as cancerous cells' growth. Moreover significant health impacts from pharmaceutically active products, such as ingredients of birth control pills and of anti-depressant and anti inflammatory medications may lead to unidentified chronic health effects in humans when consumed through sea foods (Hauke, et al., 2008).

Moreover Polycyclic Aromatic Hydrocarbons (PAHs) are also well known genotoxic. Study of the meconium of 135 newborns with congenital heart disease and 432 newborns without congenital heart disease shows 82% had evidence of intrauterine exposure to chemicals of crude oil. Moreover another study reported that polycyclic aromatic hydrocarbons can cause sperm dysplasia leading to chromosomal abnormalities in future generations (McCarver, 2011; O'Hanlon, 2010). Table 2 shows the critical review of comparison of Petroleum Hydrocarbon in sediments of selected marine areas by Venkatachalapathy (Venkatachalapathy, Veerasingam, & Ramkumar, 2010).

Finally literature review shown enormous carcinogenic and genotoxic effects of radioactive substances on the human body. They remain radioactive for many of years in the entire environment and responsible for childhood disability mostly with adverse pregnancy outcomes. Although radioactive pollutants discharged from power plants and weapon testing is less important issue of developing countries, the effects are obvious even throughout the world due to its transboundary transportation (UNEP-CEP, 2011).

2.2 Economical penalties due to Childhood Disabilities

Literature review shown annually 2.2 to 13.9 billion USD was lost due to loss of child intelligence from heavy metal poisoning in USA (Trasande, Landrigan, & Schechter, 2005). And globally 11.6 billion USD/year is lost due to consumption of contaminated seafood (\$4,000/DALY- this includes sea food induced infectious diseases e.g. hepatitis) (Shuval, 2003).

In 1995 the Japanese Government paid 2.6 million JPY (33 thousand USD) to about 12,700 victims of Minamata tragedy (Yasuma, 2010). It has been fifty-five years of this ongoing tragedy by the means of Congenital Minamata disease, but still the knowledge of industrial waste poisoning is unfamiliar to many developing countries, where environmental policies are weak and corrupted. As a result heavy metal, chemical and radioactive substances are silently contributing to global economical penalties by their transboundary qualities through oceans.

3. Discussion

All pollutions meet the ocean at the point of coastal zone what is the most dynamic and transitional zone in the earth, where land meets the ocean. Moreover coastal zone is the most resourceful area that provides a large number of people's livelihood. Therefore coastal pollution impacts on human health easily in both acute and chronic state. Importantly this pollution and health impacts represent a vicious cycle due to their interdependency (Baird, 2009).

Nevertheless oceans' linkages with human health in both positive and negative senses are by reason of exposure i.e. nature of the exposure and the characteristics of the exposed populations. People are exposed to coastal nutrients, pathogens, and other agents associated with the oceans through a variety of pathways, including direct contact with or ingestion of sea water during work, recreation, or inundation events; consumption of seafood; and exposure to ocean-borne agents in off-shore sand, sediments, or air even (Giroult, 1995). Moreover people with underlying diseases or inherent genetic susceptibilities may react differently to equivalent exposures. The response depends on an individual's genetic makeup, physiological characteristics, and personal lifestyle as well as the route of exposure, and the dose. For instance children and pregnant women are considered the more susceptible population. The physiological systems of children and fetuses are developing fast and usually sensitive to disruptions induced by environmental pollutants. Moreover small children are more likely to hand-to-mouth behaviour that puts them at increased risk of swallowing pollutant-contaminated and exposures in utero increase the risk of future toxic insults. Therefore pregnant women and children are considered most vulnerable of coastal pollutants.

Although socio-economic factors can be notable contributing factors, these can play a significant role in promoting human exposure to water pollutions. Evidently, poverty is a crucial factor adversely affecting provisions of mitigation measures of water pollutions as well as health services in many developing countries. For instance poverty involves coastal residents especially children to risky jobs like ship demolition (where most of the labourer are less than ten years of age), shell and coral collection from the beach, solid waste separation from the dumping area and so on (Mashreque, 2005). Young children of the poor mothers spend times playing in the ocean water or even in the ship yard while mothers remain busy for livelihood. Moreover fish and sea foods are the main dietary protein in many developing countries like Bangladesh, Sri Lanka, Maldives, Brazil, Thailand etc (Hussain & Hoq, 2010). Thus a large proportion of the poor coastal residents are continuously exposed to the heavy metals and chemicals globally.

A number of studies are conducted on coastal pollution in developed countries but regrettably it is still ignored in the developing countries, where environmental policies and precautions are minimal. In the developing world only 10-15% waste water is treated and this huge untreated waste water contains pathogens, chemicals, heavy metals and other noxious agents (Giroult, 1995). After discharging into the ocean they transport transboundary and accumulate in the human food chain. Thus coastal pollution is contributing on global burden diseases by increasing rate of childhood disability incidences besides infectious diseases as well. Therefore coastal pollution has become a public health emergency especially during coastal water related disastrous events (e.g. storm surge, tsunami, coastal flood, astronomical high tide, sea level rise), when polluted sea water contaminates ground or surface water and sediments.

5. Conclusion

Globally the state of present knowledge about the linkages between oceans and public health varies. Some risks, such as those posed by harmful algal blooms' toxins, or naturally occurring toxins poisoning, are relatively well understood. But other risks, such as those posed by chronic exposure to many anthropogenic chemicals, consumption of seafood contaminated with heavy metals, are less well enumerated. Good epidemiological data are often lacking. Solid data on economic and social consequences of these linkages are also scattered, incomplete and sometimes difficult to access. Whereas policy and development planning relies on this information.

Considering the main effects on human health, global burden is increasing by the means of disability among both child and adult. Finally, more than fifty percent poor population lives in the developing countries where health service is already scarce (Giroult, 1995; Hanifi & et al, 2010). Therefore health burden due to a wide variety of coastal pollution is remaining unresolved in the developing countries.

Since this connection is a new field of public health, global attention is required to address this crisis and emphasis must also be given to education and training of future researchers, policy makers and general people to change harmful attitudes that contribute to the coastal pollution.

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Juma Rahman has graduated Masters Degree in Public Health (Global Health) from Thammasat University, Thailand on 2011. She completed her MBBS (Bachelor of Medicine, Bachelor of Surgery) degree from Faridpur Medical College, Bangladesh on 2003. Her research interests include public health, environmental health, public health emergency and policy analysis.

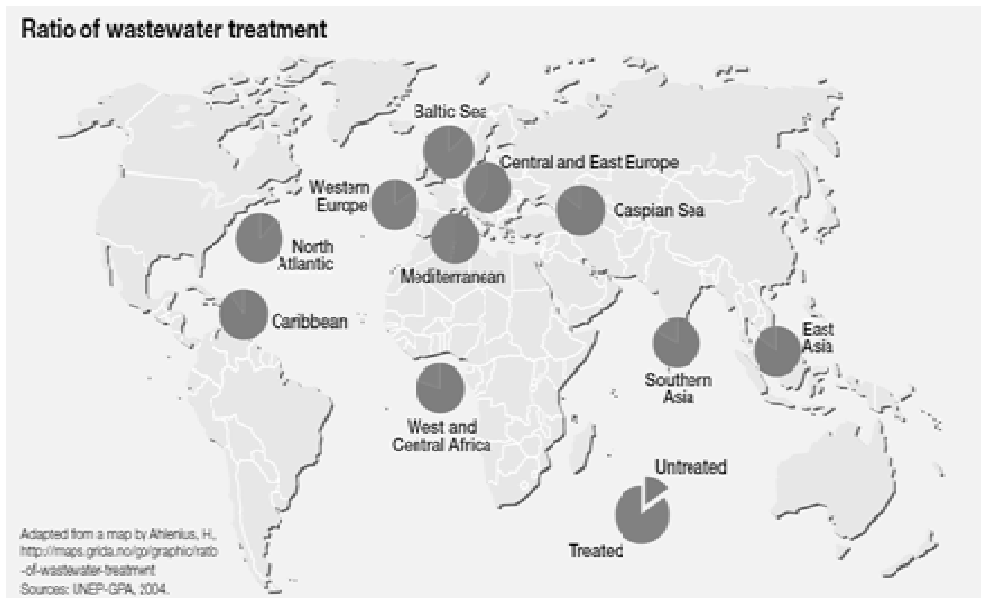


Fig: 1 – The global map showing the ratio of treated and untreated wastewater reaching water bodies for 10 regions. Source UNEP (2006)

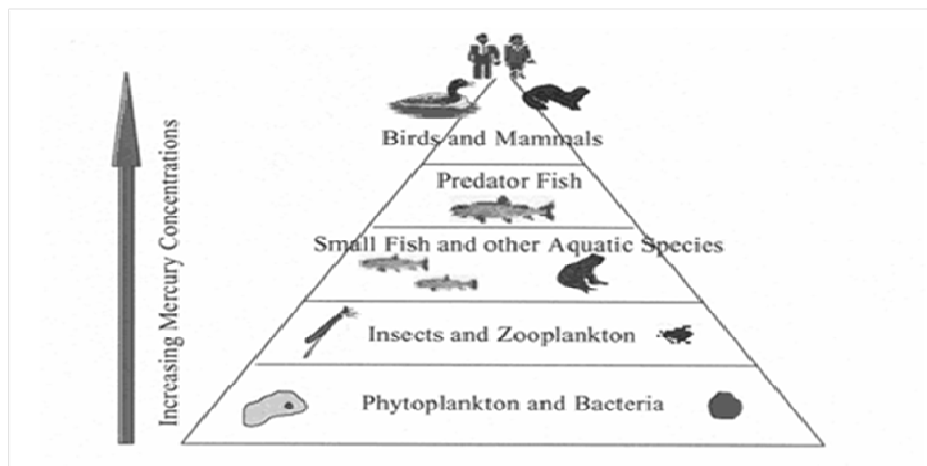


Fig- 2: Accumulation of Mercury in the food chain. Source: National Wildlife Federation (2000).

Table-1: Metals in the grains grown on contaminated soil measured in micro gm/kg

Heavy Metal	Wheat			Rice			Permissible limit in grain
	Root	Shoot	Grain	Root	Shoot	Grain	
Cr	376	5.4	<5	4702	112	<5	2.83
Cu	9.9	4.2	9.7	4.0	6.3	4.3	1.36
Mn	19	10	15	161	125	34	NA*
Zn	129	57	118	276	121	03	9.43-15.78

*NA= Not Available. Source: Huq (1998).

Table-2 Comparison of Petroleum Hydrocarbon (PHC) in sediment of selected marine areas measured in ppm (parts per million).

Location	PHC	References
Abu Dhabi,UAE	6.14-62.7	Abd et al. 2008
Arabian Gulf	5.4-92.0	Al-Lihaibi and Ghazi, 1997
Arabian Sea along the Indian coast	0.6-5.8	Sengupta et al. 1993
Bassein-Mumbai coast, India	7.0-38.2	Chouksey et al. 2004
Bizerte lagoon, Tunisia	0.05-19.5	Mzoughi et al. 2005
Changjiang estuary, China	2.2-11.82	Bouloubassi et al. 2001
Fraser River Basin,Canada	1.6-20.6	Yunker and Macdonald Robie, 2003
Gulf of Fos, France	7.8-180	Mille et al. 2007
Jiaozhou Bay, China	0.54-8.12	Wang et al. 2006
Shetland Island, UK	7.0-8,816	Kingston et al. 1995
Straits of Johor, Malaysia	0.7-36.7	Abdullah et al. 1996
Tamilnadu coast, India	1.48-4.23	Veerasingam et al. 2010
Thane Creek, India	7.6-42.8	Chouksey et al. 2004
Chennai coast, India	1.8-39.72	Venkatachalapathy, 2010.

Source: Venkatachalapathy (2010).

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