

Review

Water pollution: A review of microbial quality and health concerns of water, sediment and fish in the aquatic ecosystem

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This paper reviewed aquatic ecosystem pollution with particular reference to pathogens in water, sediment and fish and their human health concerns. It highlighted the historical perspective of the relationship between microbes and humans regarding the “ranging war” between them, arising from the reckless exploitation of the biosphere by humans and the resultant “revolt” by microbes in the form of various pathogenic diseases that now plague mankind. Also highlighted are pathogens and diseases in both wild and cultured fish, citing reported cases in Nigeria to include *Salmonella*, *Shigella* and *Leptospira* spp., *Proteus vulgaris*, *Escherichia coli*, *Citrobacter diversus*, *Pseudomonas fluorescens*, *Aeromonas hydrophilla*, *Staphylococcus aureus*, *Klebsiella aerogenes*, *Edwardsiella tarda* and *Flexibacter columnaris*. Some human diseases contacted from contaminated/infected fish and fisheries’ products that have been reported in Nigeria were reported to include: food poisoning and gastroenteritis, diarrhea, bacillary dysentery, typhoid and paratyphoid, clonorchiasis and superficial wound infections and ulcers. In conclusion, the paper reviewed the modes of infection of water related and fish-borne diseases of human health concerns and recommended ways to ameliorate their infection and spread.

Key words: Pollution, microbial quality, health concerns, aquatic ecosystem.

INTRODUCTION

The war ranging between mankind and microbes is continuous and unending, so says a foremost professor of medical microbiology (Agbonlahor, 1998). He wrote:

“God created Mankind and Microbes and left them to live happily in the beautiful earthly garden. They all sinned and their Maker was angry. He ordered them to, thereafter struggle for their continuous existence and survival here on earth. In the process, Mankind Exploited and Microbes Revolted, thereby ensuring a continuous conflict or war between them.”

Mankind’s reckless exploitation of the biosphere has been aptly summarized by Armelagos (1998) as follows:

“In the past three decades, people and their inventions have drilled, polluted, engineered, paved, planted and deforested at soaring rates, changing the biosphere faster than ever before. The combined effects can, without hyperbole be called a global revolution. After all, many of them have world-wide repercussions: the widespread chemical contamination of waterways, the thinning of the ozone layer, and the loss of species diversity”.

Microbes “Revolt” or “Retaliation” against man’s exploitation interpreted by them as “act of aggression” on the ecosystem which adversely affect them, came in the form of widespread outbreaks of diseases: the Bubonic plague caused by *Yersinia pestis*; the Yellow fever, Measles, Influenza pandemic which killed over 21 million people world wide, Anthrax, Cholera, Meningitis, etc. Recent cases of AIDS (HIV virus), Lassa fever, Ebola fever, Mad-cow disease, Bird flu and Swine (Pig) flu are all part of the “Revolt” (Agbonlahor, 1998).

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WHAT ARE MICROBES?

The new edition of the Chambers English Dictionary defines microbes as microscopic organisms. The word microbes or micro-organisms refer to a group of extremely tiny living organisms, which can only be seen with the aid of a microscope (Agbonlahor, 1998). Microbes consist of bacteria, fungi, viruses and protozoa. They are adapted to the various environments on earth: some living in water, some in soil, others in air, plants and animals including man. According to Rosebury (1961), microbes are not only ubiquitous in human, but they also abound in numerous numbers on and in his body, while he is in the best of health. Those that cause diseases are called Pathogens.

It is common knowledge that humans and microbes have a long history together. The normal microbial flora consists of organisms that make their home on or in some part of the body. In a healthy person, such organisms rarely cause disease. Microorganisms of the normal flora may be in symbiotic relationship, where both microorganism and host benefit e.g. the enteric bacteria that form normal flora of the intestine, assist in the synthesis of vitamin K and some of the vitamin of the B complex; or in commensalism, where they are neither beneficial nor harmful to their host e.g. the large group of normal microbial flora that live on the skin and the mucous membranes of the upper respiratory tract, intestines and vagina (Cheesbrough, 2000). Apart from being symbionts and commensals, microbes may also be opportunists, a situation where a normal flora, if a suitable opportunity arises, becomes pathogenic and cause disease.

Medically, pathogenic bacteria are classified based on their Gram reaction, morphology, whether they are sporing or non-sporing (Gram positive bacteria) and whether they are aerobes (requiring oxygen to grow), facultative anaerobes (grow in conditions in which oxygen is present or absent), anaerobes (unable to grow in free oxygen) or microaerophiles (grow best under reduced oxygen conditions) (Cheesbrough, 2000).

AQUATIC ECOSYSTEMS AND MICROBES

Pathogens are ubiquitous on earth (Agbonlahor, 1998; Cheesbrough, 2000). In the aquatic ecosystem, they are found in all the environmental compartments: water, sediment, aquatic plants and animals.

Pathogens in water

Surface waters

Water is essential to all living organisms including pathogenic microbes. Man, in his effort to get rid of his wastes

have introduced into natural water bodies, noxious substances including organic wastes that promote the growth of pathogenic bacteria, fungal, viral and protozoan microbes (Adams and Kolo, 2006).

In recent times, Environmentalists have become increasingly concerned about the pollution of surface waters. The World Health Organization (WHO) estimated that about 80% of ill-health especially in developing countries are water related (Cheesbrough, 2000). The access of faecal matter to water through direct contamination of surface run-off or sewage may add a variety of pathogens. Atiribom et al. (2007) reported that high concentrations of bacteria and nitrates discharged into water can occur from animal husbandry operations like grazing and that this can result in health hazards to man due to the presence of pathogens. Hubbard et al. (2004) reported that nitrates' concentrations in excess of 10 mg/l render water unsuitable for drinking and could lead to the health condition known as methemoglobinemia (blue baby) in infants.

Wastes from agricultural operations, which are usually discharged into surface waters have been reported to have serious environmental and human health concerns (Adams and Kolo, 2006). Aquaculture, an aspect of agriculture that deals with the rearing of fishes, has been reported to exert a diverse range of impacts on the environment. Some of these include large scale introductions of fish species into areas outside their native range, which could lead to the emergence of feral populations. Other problems that could arise include degradation of host environment, disruption of host community, competition with existing species, predation and possible elimination of local species (biodiversity). Some other risks associated with exotic fish introductions are genetic degradation of host stock, stunting, deterioration in the quality of indigenous stock, introduction of diseases and parasites and socio-economic consequences (Welcomme, 1988). Amlacher (1961), opined that intensive aquaculture carry much greater risks of serious aquatic disease outbreaks. It has greater needs for water treatment chemicals and drugs for disease prophylaxis and treatment, which could lead to the development of resistant strains of human pathogens in adjacent waters (Akolisa and Okonji, 2005).

Underground water

Water from bore-holes, wells and springs are referred to as underground. It is generally accepted that underground water is purer than surface water because of the straining action of rock as water percolates through it (Ademoroti, 1996). Studies have shown that underground water pollution occurs by seepage of pollutants through the soil and by contaminants migration from surface waters. Some water-borne diseases obtained through ingestion of pathogens in drinking water or contaminated

water getting to the mouth from washing utensils and hands. Such type of water arises from streams and open wells that are easily polluted. In many developing countries, the use of dirty bucket and rope to fetch water from deep wells has led to the incidence of diseases (Ademoroti, 1996). The use of soakaways for the disposal of domestic and industrial effluents and even citing of refuse dumps for both domestic and industrial solid wastes may impair groundwater quality unless there is an impermeable stratum between the disposal area and the groundwater table. Ademoroti (1987) reported the contamination of well water by *Vibrio cholera* and coliform bacteria from many Nigerian cities and villages and recommended that a minimum of 30 m must separate a well from a soak-away site.

Water-borne diseases

Most of the mortality and morbidity associated with water-related disease especially in developing countries is due directly or indirectly to infectious agents which infect man through:-

- i. Ingesting pathogenic bacteria, viruses or parasites (protozoans and helminthes) in water polluted by human or animal faeces or urine. Diseases in this category include cholera (*Cholera vibrio*), shigellosis (dysentery caused by *Shigella* spp.), typhoid (*Samonella typhi*), paratyphoid (*Samonella paratyphi*), diarrhea (*Escherichia coli*), hepatitis (Hepatitis virus) and poliomyelitis (Polio virus).
- ii. Diseases associated with scarcity of water for personal hygiene (bathing, hand washing), laundering clothes and cleaning of cooking utensils. In this category of diseases are scabies, yaws, skin ulcers, conjunctivitis and trachoma.
- iii. Diseases associated with ingestion or penetration of human skin by infective forms that require a snail, fish or other aquatic hosts. Examples include schistosomiasis, clonorchiasis and paragonimiasis (cercariae ingested in crabs, crayfish and fish).
- iv. Diseases from being bitten by insect vector which breeds in or around water. They include malaria, dengue, yellow fever, filariasis (mosquito-borne); trypanosomiasis (tse-tse fly-borne) and onchocerciasis (black fly-borne).

Pathogens in sediment

Sediment refers to the earth or soil at the bottom of water bodies. Sediment is formed from materials deposited by water. Most pathogens found in water and aquatic organisms are also found in water sediment. Hence dredging which is the removal of sediments or earth ("spoils") from the bottom of water bodies using either a type of scoop or a suction apparatus can disturb the natural ecological

balance through the direct removal of aquatic life. In the freshwater environment, the removal of "spoils" could lead to the elimination of bottom dwelling microorganisms on which fish depend for food from the food chain. Furthermore, contaminants including pathogens and toxic substances which accumulate in the sediment can re-enter the water system when the sediments are dredged (Canadian Water Quality Guideline, 2002). Such pathogens and toxic substances then endanger the health of the users, particularly fish and man through their ingestion in food and drinking of contaminated water.

A major activity in aquaculture is the application of cow dung, poultry droppings to pond bottom as manure during pond fertilization. Such activities and the direct deposition of human faecal wastes in water bodies in man's disposal effort, lead to contamination of water bodies with pathogens and other toxic substances. Atiribom et al. (2007) reported the isolation of pathogenic organisms: *Aeromonas hydrophila*, *Escherichia coli*, *Samonella typhi* and *Shigella* spp. from cow dung manure in the sediment and surrounding of the Kainji Lake. Cases of tetanus infections caused by *Clostridium tetani* from contaminated soils have been reported in many developing countries (Cheesbrough, 2000). It is conceivable that tetanus infections will also be common among fish farmers especially during re-working and fertilization of pond bottom with animal wastes which are often carried out in-between fish production circles. Sediments containing decaying organic matter are the natural habitat for most pathogenic organisms especially bacteria and fungi (Williams and Wilkins, 2001).

Pathogens in fish

In the past, it was thought that fish harvested from open waters (marine and fresh) were generally safe, principally because of the practice of quick chilling of fish and fisheries products soon after harvesting. This notion, according to Reilly (1992) was borne out of the lack or paucity of epidemiological evidence of fish-borne diseases. Recent evidence from fisheries reports and studies in the areas of water pollution, fish handling and preservation, water management/fish feeding practices in aquaculture and some cultural practices of fish preparation and raw fish consumption suggest otherwise (Mitchell and Chel, 1978; WHO, 1995; Howgate, 1997; Reilly et al., 1997; Ikpi et al., 2005; Atiribom et al., 2007).

The expansion of fish production facilities in the effort to meet animal protein supply through increased fish production has placed increased requirements of quality and product safety on producers, marketers and regulators. This assertion was emphasized by lhuahi and Omojowo (2005), which opined that the issue of quality and safety of fish and fisheries products has become of serious concern to consumers and regulators in both producing and importing countries.

Pathogenic microbes cause many diseases in both wild and cultured fish. They may vary from a primary pathogen to that of an opportunist invader of a host rendered moribund by some disease process (Inglis et al., 1994). Fish may harbour pathogens on or inside its body after exposure to contaminated water or food. Disease is an unwholesome condition manifested by the departure of the body from the normal health state causing discomfort that may lead to death. The study of diseases of fish is hindered by the lack of adequate understanding of the ecological processes involving interactions between pathogens and their hosts in the aquatic ecosystem as well as the ill-understood physiological features of fish, characterized by their poikilothermy in contrast with the better understood physiology of homeothermic animals (Nyaku et al., 2007).

Most common pathogens in fish include: *Samonella*, *Shigella*, *Leptospira*, *E. coli*, *Vibrio*, *Mycobacterium* spp., Viruses and Hookworm larvae. Mitchell and Chel (1978) isolated *Samonella* and *Shigella* species from fish of River Nile. Ikpi et al. (2005) reported the isolation of eight bacterial pathogens (*Pseudomonas florescens*, *Aeromonas hydrophilla*, *Proteus vulgaris*, *E. coli*, *Staphylococcus aureus*, *Klebsiella aerogenes*, *Edwardsiella tarda* and *Flexibacter columnaris*) from cultured fishes in Obubra, Nigeria.

In aquaculture, the outbreak of disease is generally associated with ill-effective husbandry because the disease-causing agents present little problems until the fishes are stressed due to improper feeding and/or other adverse environmental conditions and predation (Nyaku et al., 2007). In intensive aquaculture, disease tends to spread relatively easily because of the high density of stocking and intensity of feeding in limited water areas, the proliferation of disease-causing agents through the common water source between ponds, farms and the stocking of fish fry/fingerling/broodstock transported from other fish farms without adequate precaution, can spread diseases (Akolisa and Okonji, 2005). Diseases could cause financial losses in fish culture as the risk of complete loss of crop tends to be higher than in other agricultural activities. According to Wooten (1997), diseases do not only cause mortalities in fish, but also cause loss of growth, reduction in fecundity as well as loss of product quality. Some specific cases reported in many fishes in Nigeria include loss of pigmentation, muscle degeneration and necrotic lesions and ulcerations (Ikpi et al., 2005). Indeed disease has become a primary constraint to aquaculture growth and is now severely impacting both economic and socio-economic development in many countries of the world (Subasinghe and Bernoth, 2000).

Fish pathogens and human diseases

Most bacterial species cause different diseases in fish. Some of them cause diseases in humans. Human diseases that can be caused by bacteria in fish include:-

1. Food poisoning and gastroenteritis caused by *Samonella*, *Vibrio* and *Clostridium* spp., and *Campylobacter jejuni* (Davis et al., 1967).
2. Diarrhoea caused by *Edwardsiella* sp., *Staphylococcus* sp., *Escherichia* sp. and *Aeromonas* sp. (Davis et al., 1967; Inglis et al., 1994).
3. Superficial wound infections, ulcers, etc, due to *Pseudomonas* sp. (Ikpi et al., 2005).
4. Bacillary dysentery (Shigellosis) caused by *Shigella* sp. (Cheesbrough, 2000).
5. Clonorchiasis, Dracunculiasis and Paragonimiasis due to larvae and metacercariae ingested in fish and crustaceans (Cheesbrough, 2000).
6. Cholera caused by *Cholera vibro* (Atiribom et al., 2007).
7. Typhoid and Paratyphoid due to *Samonella typhi* and *Samonella paratyphi* (Nyaku et al., 2007).

CONCLUSION AND RECOMMENDATION

A historical perspective of the relationship between humans and microbes has been presented. Pathogens in water, sediment and fish and their infections were reviewed and discussed. Issues arising from fish disease infections in relation to fish health, productivity from wild and cultured fish, socio-economic and human health impacts were also discussed. To ameliorate these impacts and ensure good health, the following recommendations have been made:-

- i. Man's onslaught through pollution and direct alteration of the aquatic ecosystem should be regulated to minimize impacts.
- ii. Environmental factors (physical, chemical and biological) that can adversely affect the health of fish and cause fish diseases and death should be avoided.
- iii. Measures to prevent the contamination of drinking water and food and adequate preparation of fish for human consumption should be encouraged.
- iv. Provision of adequate water supply, improvement in personal hygiene, destruction and control of disease vectors and their habitats should be routinely carried out to prevent the multiplication and spread of disease pathogens.
- v. Epidemiological investigations into pathogens of fish and humans, their virulence, treatment and above all their prevention should be intensified.

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