

Waterborne Zoonotic Bacterial Pathogens: Review

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Abstract

Zoonoses infections are among the major public health issues confusing, as pandemics emergencies intermittently causing significant global human and economic losses. The aim of this review is to summarize the most prominent waterborne bacterial pathogens of zoonotic origin, along with basic prevention methods. Excretions and waste products are most sources of waterborne zoonotic pathogens, as these substances are used as a means of transmission from the animal to the aquatic environment. Water is one of the ways of transmission of infection, especially through drinking water. Among these life-threatening bacterial pathogens is *Bacillus anthracis*, *Campylobacter jejuni*, which causes enteritis in humans and animals, *Escherichia coli* that causes hemorrhagic enteritis, *Salmonella enterica* that lead to enteritis, and *Vibrio cholera* which causes gastroenteritis and blood poisoning, may lead to death. For prevention, zoonotic pathogens must be controlled in animal reservoirs, along with proper disposal of animal waste as well as protecting surface water from animal waste and also sterilizing drinking water. In this review, we concluded the need to apply the qualitative approach to sterilization of drinking water according to international standards.

Keywords: Zoonoses infections, drinking water, bacterial pathogens.

1. Introduction

Zoonoses can be explained simply as infections that are transmitted between animals and humans, as more than 60% of infectious diseases that affect humans are of animal origin [1-3]. In developing countries, people depend heavily on animals for food, which increases the risk of transmission of zoonotic diseases, especially in rural communities, as a result of the frequent interaction between humans, livestock and poultry [4]. In general, zoonotic infections groups include firstly viral pathogens such as Corona, Monkey pox, and Ebola [5-8]. Second group are bacterial pathogens such as Anthrax, *Campylobacter*, and *Escherichia coli* [9]. Last group are parasitic pathogens as Giardiasis [10]. There are several pathogens that can be transmitted through water, including zoonosis. The pathway of waterborne transmission may be either limited or critical [11]. Health risks from waterborne zoonotic diseases must be viewed in the context of the general level of gastrointestinal or other disease. Excretions and waste products are the predominant sources of waterborne zoonotic pathogens, as these substances are used as means of transport from the animal to the aquatic environment [12]. In general, wastewater is considered one of the main sources of pathogens, and water is one mode of transmission. The transmission of waterborne zoonotic pathogens occurs through: drinking water, contact with water, and using water for food preparation and processing [13,14]. Identification of the causes and routes of transmission of waterborne infections is necessary to implement appropriate control mechanisms [15]. The aim of this review is to clarify the important information available about some waterborne zoonotic bacterial infections.

2. Waterborne Zoonotic Bacterial Pathogens

2.1 *Bacillus anthracis*

It is a soil-borne, Gram-positive, spore-forming bacterium that causes anthrax, a fatal infection for mammalians. Anthrax word originated from the Greek language, anthracites, which mean coal, in reference to the black coal-like lesions seen mainly in human cases of cutaneous anthrax. Anthrax spores may remain viable in the soil for a long period of time and can be dispersed by wind, predators, fertilizers, or effluents from factories that process contaminated animal products [16]. Anthrax outbreaks caused the death of large

numbers of animals, which led to continued economic losses for communities living in areas of interaction between livestock and wildlife in several regions of the world, especially remote ones. This disease also causes a lot of suffering to humans, who may be associated with deaths, especially for vulnerable groups in society such as children, women and the elderly [17]. In addition to its importance as an infectious disease, the anthrax bacterium is also a major agent associated with biological warfare and terrorism [18]. Some studies have shown that lowlands, which are prone to flooding, are the hotspots for anthrax outbreaks. It is also related to temperature, precipitation, drought, soil type, and vegetation cover. It is worth noting that when water contaminated with anthrax spores is ingested (figure 1), they reach the bloodstream and release toxins that cause systemic effects [19]. Anthrax is a life-threatening disease and public health confounder so a joint surveillance system using the One Health approach is required by initiating a joint anthrax reporting system and outbreak investigations [20].

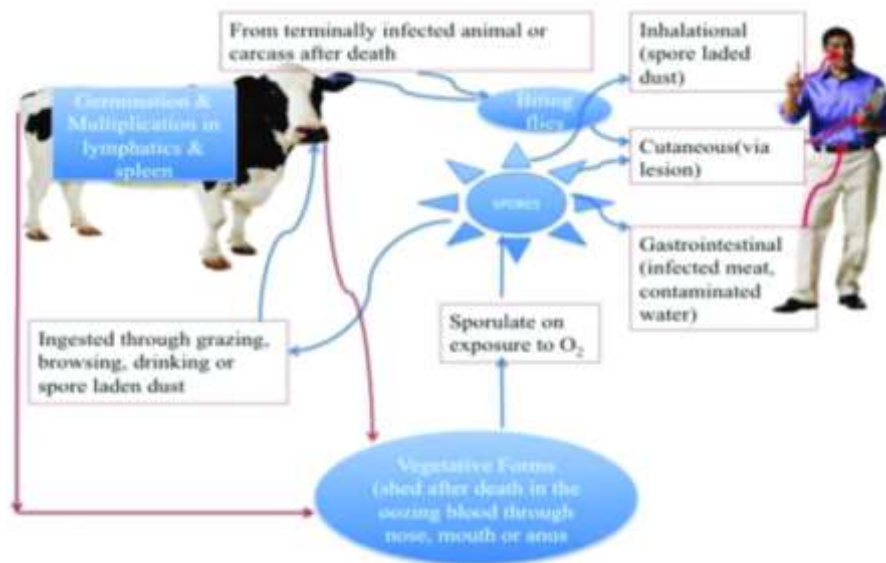


Figure 1: Methods of infection of humans and animals with anthrax bacterium.

2.2 Campylobacter jejuni

Campylobacter jejuni is a Gram-negative, motile, non-sporophyte, oxidase-positive bacterium. It is a major cause of foodborne bacterial disease in many developed countries and an opportunistic pathogen in humans and the most important symptoms of infection are diarrhea or dysentery syndrome along with fever and pain [21]. In general, *C. jejuni* causes enteritis in mammals. It is also the main cause of spontaneous abortion in cattle. These pathogens can be transmitted to humans via consuming raw or poorly cooked contaminated food, and consumption of contaminated water (figure 2). It has been proven that these bacteria live in an aquatic environment for few weeks [22].

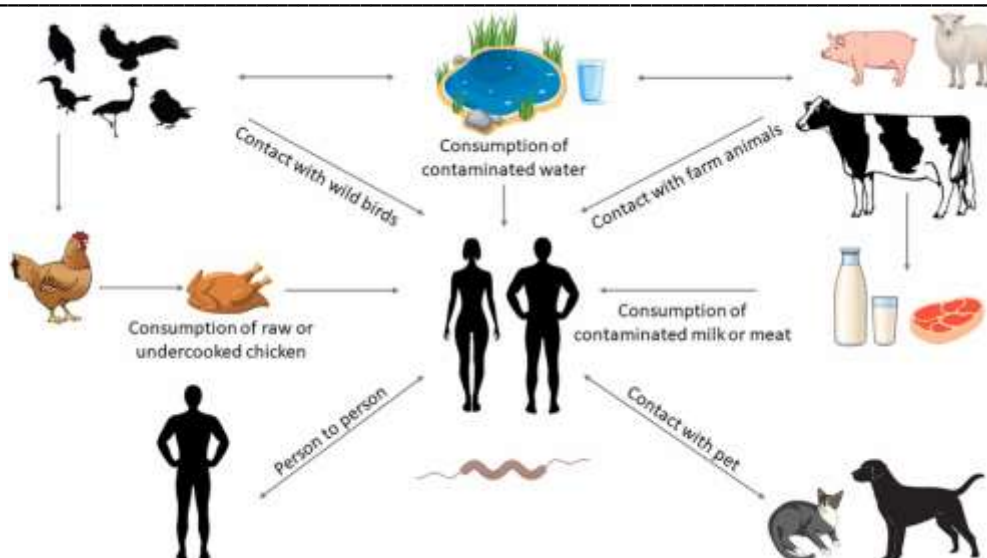


Figure 2: Modes of transmission with Campylobacter species [23].

2.3 Escherichia coli

It is rod-like, motile, non-spore, Gram-negative bacterium, and lives in the intestines of humans and animals (benign symbiosis of warm-blooded organisms). The majority does not pose a pathological risk, however they are highly diverse bacterial species, and subtypes contain virulence factors that allow causing infections. Some subspecies of *Escherichia coli* cause internal infections especially in urinary tract, or invasive infection [24]. Enterohaemorrhagic *Escherichia coli* (EHEC) is originally a serotype that induces symptomatic disease such as *Escherichia coli* O157:H7. Also, this strain is the most specific pathogen in humans, being capable of producing potent cytotoxins or verotoxins and causing lesions in the cecum and colon, and is a major cause of diarrheal illness in humans and pets. Ruminants, particularly cattle, are the main reservoir for *E. coli* [25]. The most prominent symptoms of acute gastrointestinal hemorrhagic infection are watery diarrhea as well as fever. In advanced cases, life-threatening syndromes may develop. *E. coli* is transmitted to other animals by contaminated feed, handling and drinking water, and can also be transmitted to people from animals by direct contact or orally with contaminated food or water (figure 3). Waterborne transmission is a key way of infection in the most endemic countries, and it results from water contamination with human faeces [26]. *E. coli* O157:H7 has a low infective dose, allowing water to act as an effective medium. It should be noted that watersheds subject to intrusion by animals are at hazard of pollution. Thus, tiny water stores or wells supplying towns or rural camps were generally associated with outbreaks of waterborne diseases [27]. Additionally, recreational waters are often engaged in in the spread of infection. Feces (human or animal) or sewage are sources of infection. In fact, because of the low infectious dose of this bacterium in waters, a high risk of infection may arise [28].

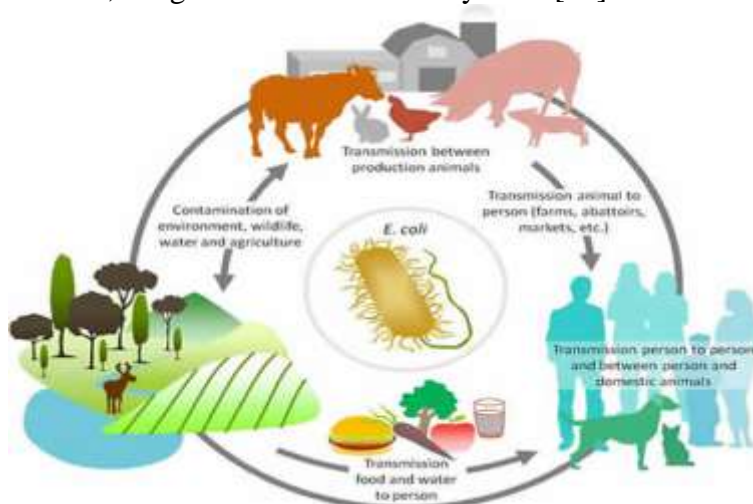


Figure 3: Modes of *E. coli* transmission.

2.4 Salmonella Species

Salmonella are microorganisms that usually parasitize the intestines of humans and animals alike, and even rodents. They are frequently found in sewage, rivers, and other waters and soils, and if appropriate environmental conditions are obtainable, it stays for weeks in the water and for years in the soil. They are pathogenic to many animal species, and lead to enteritis and typhoid-like diseases [29]. The spread of these bacteria depends on the water supply as well as waste disposal. It is a facultative anaerobic, Gram-negative, non-enveloped, non-spore-forming, mostly motile bacilli bacterium from the Enterobacteriaceae family. All pathogenic Salmonella species in contrast to *S. Typhi* produce gases. It residing in the digestive tract of animals is transmitted to humans through ingestion of contaminated food and water in most cases of infection. Most of the mammalian pathogenic serotypes belong to the Salmonella enterica, which is a zoonotic pathogen of great concern to human and animal health worldwide. It is a major cause of morbidity and mortality with gastroenteritis among people all over the world [30,31]. Poultry is a major source of salmonellosis in humans, as they are asymptomatic or latently infected carriers, or in lesser cases clinically ill. It should be noted that the infection is restricted to the digestive system, and for this reason the bacteria are excreted in the feces and serving as a big reservoir of contamination for the environment [32]. Salmonella transmission via water (figure 4) can be qualified using the following elements: the source of the infectious agent, specific modes of transmission related to water, traits of the organism that allow adaptation in the aquatic environment, virulence factors with the infectious dose, and finally factors related to host susceptibility[33].

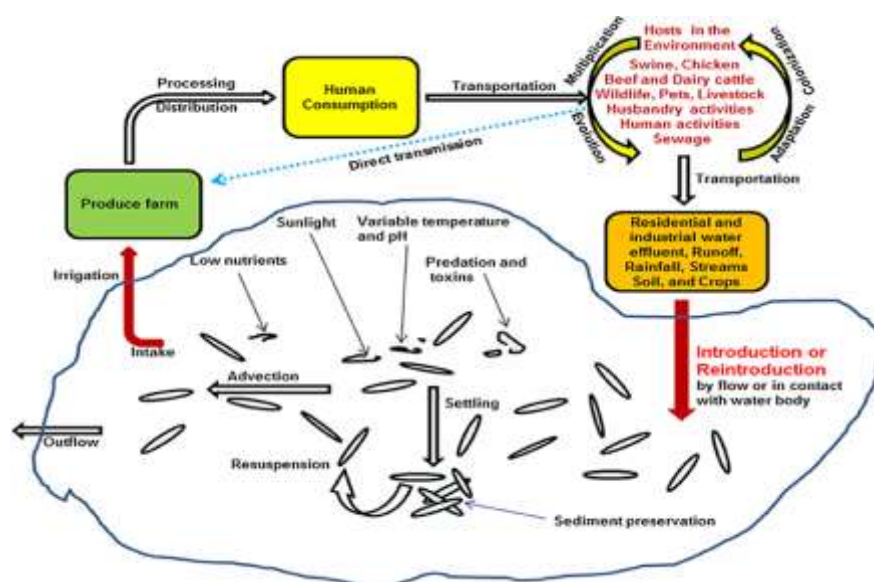


Figure 4: Salmonella transmission by irrigation water [34].

2.5 Vibrio cholerae

It is a curved, facultative anaerobic, non-spore, highly motile with polar flagella, Gram-negative bacterium. It is divided into serogroups depending on the physical antigens. It causes gastroenteritis, such as watery diarrhea, vomiting, dehydration, septicemia, and death. Cholera is a typical of complex bacterial and environmental infections. In areas with poor sanitation it leads to the return of *V. cholerae* to the environment, and so the life cycle of *V. cholerae* includes frequent exchange among aquatic environments and the host digestive tract [35,36]. This bacterium lives mostly in fresh water (figure 5), and the prime transition of *Vibrio* infection is by consuming of poor or uncooked shellfish or contact of exposed wounds with warm seawater [37].

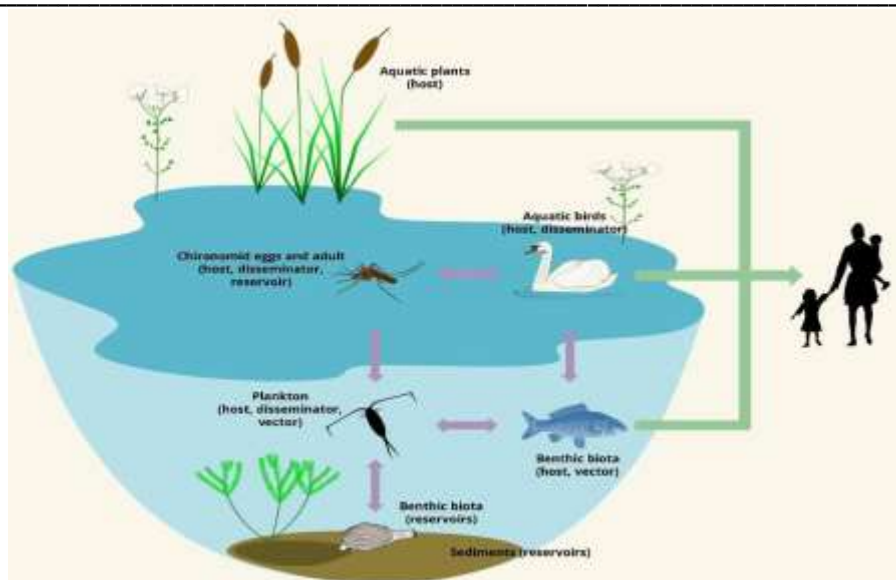


Figure 5: Potential reservoirs of *V. cholerae* in aquatic environment [38].

3. Prevention and control

The first control measure is the control of zoonotic pathogens in animal reservoirs, by implementing the following correct essential procedures: Providing clean housing, food and water for animals, and protecting them from infection by preventing them from contact with other potentially infected animals, beside to the auxiliary role of antimicrobial use, active and passive immunization [39,40]. In addition, efforts must be unified worldwide to solve the problem of proper disposal of animal waste, including from slaughterhouses. Protecting surface waters from animal droppings applied to fields is a critical step in preventing the dispersal of waterborne zoonotic microorganisms [41]. Heavy rainfall has a role in the spread of water-borne zoonotic diseases through the transfer of contaminated animal waste and soil to surface water and well water. Water contaminated with animal waste poses a risk of infection for individuals who consume untreated drinking water, so it is imperative to protect and treat drinking water [42]. Multiple barriers are supposed to be used to protect water sources as well as drinking water distribution systems[43]. To implement water-borne zoonosis prevention strategies, the efforts of the various responsible disciplines must be unified, such as human health, animal health, the environment, and even municipal planning.

4. Conclusions

There is a clear global embarrassment of zoonotic pathogens, and fear of a new pandemic that will cause huge human and economic losses. Therefore, this review is an alert to the need to apply the approach to sterilizing drinking water qualitatively according to international standards, especially in developing countries that are still suffering from the occurrence of these infections.

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