review of literature
2. REVIEW OF LITERATURE

Cholera has been recognized as a killer disease since earliest time. Since 1817, six pandemics have swept over the world, and the seventh one is in progress. Epidemics of cholera began to occur in the 17th and 18th centuries in India and elsewhere, and the first pandemic of multi-national disease began in 1817. The modern history of cholera also began in 1817. The classical research of Koch (1884), taken together with the microbial ecology studies of Colwell et al. (1977), provide overwhelming evidence for the aquatic existence of *Vibrio cholerae*. During the cholera epidemic of 1854 in Florence, the Italian physician Filippo Pacini (1812 to 1883) discovered the first *Vibrio* species *V. cholerae*, the causative agent of cholera and this was witnessed by Fetter et al. (1969) in their study about the morphology and round body formation in *V. marinas*. Pacini’s important discovery was overshadowed by the work of Robert Koch (1843-1910), a German physician and bacteriologist who studied cholera during epidemics in India (Calcutta) and Egypt (Alexandria). In 1883, Robert Koch conclusively isolated the causative agent of cholera from pond water during a cholera outbreak.

The disease is caused by infection of the small intestine by *V. cholerae* O1 and O139 and is characterized by massive acute diarrhea, vomiting, and dehydration: and death occurs in severe, untreated cases. Cholera is a highly contagious disease, and is transmitted primarily by ingestion of faecally-contaminated water by susceptible persons. Besides water, foods have also been recognized as an important vehicle for transmission of cholera. Foods are likely to be faecally contaminated
during preparation, particularly by infected food handlers in an unhygienic environment.

May (1958) had reported that only little was known about the relation of *V. cholerae* to the ecology of estuaries harboring the agent in the United States and he later on plotted the areas of cholera expansion in pandemics of the nineteenth century. Blake *et al.* (1980) reported that there was growing evidence that a reservoir for cholera disease existed in bays and estuaries and that such a reservoir encompassed the Gulf Coast of the United States.

A better understanding of the ecology would help to predict the effect of global climate change and prepare to react, and no aquatic animal reservoir had been found, although persistence in shellfish for several weeks had been demonstrated later on by Colwell *et al.* (1977).

Colwell (1996) stated that research on cholera epidemics requires a multi-disciplinary approach in order to understand the dynamics of the disease and cholera provides a useful model for how ecology, combined with medical microbiology and epidemiology, can enhance the understanding of the disease and the disease agent, *V. cholerae*.

In the beginning of the nineteenth century, there had been seven pandemics in which *V. cholerae* spreaded rapidly from endemic foci, usually in Asia, to Africa, Europe, and sometimes to North America. Pollitzer (1959) stated that cholera had been known for centuries in the delta of the Brahmaputra and Ganges rivers.

Recently, it has been suggested by Ramamurthy *et al.* (1993) that we are entering the eighth pandemic, with the emergence of the Bengal biotype, serogroup O139 and *V. cholerae* O139 was initially isolated in Madras, India in 1992. Bik *et al.*
(1995) reported that *V. cholerae* O139 was likely derived from *V. cholerae* O1 El Tor as a clonal lineage, with the exception of the deletion of O1 specific DNA and the insertion of *V. cholerae* non-O1 specific DNA.

Blake (1994) reported that, once an epidemic start of *V. cholerae*, transmission was by fecal-oral spread from carriers recovered from the disease and from asymptomatic, infected persons.

Nguyen *et al.* (2006) reported a preliminary picture of diarrhea with regards to etiology, clinical symptoms, and some related epidemiologic factors in children less than five years of age living in Hanoi, Vietnam and their study population included 587 children with diarrhea and 249 age-matched healthy controls.

CDC (1989) strongly reported that, *V. cholerae* episode was caused only because of the consumption of raw oysters from Gulf Coast focus of Louisiana and Texas in 1973 and Louisiana in 1988. In Bangladesh, the shift from cholera epidemics caused by *V. cholerae* O1 to those caused by *V. cholerae* O139 was thought to be a result of the inefficient protection of immunity acquired from *V. cholerae* O1 infections and the pathogenic properties of *V. cholerae* O139 was suggested by Morris (1994).

Colwell (1996) stated that a rise in sea level diminished river flow rates and the bays and estuaries can be expected to undergo major modifications. The temperature, pH, salinity, and composition of plant and animal life may well change drastically. This study also revealed that the focus of *V. cholerae* may thrive or may disappear as a result of these changes and however we cannot count on its disappearance.
The association of *V. cholerae* non-O1 with diarrheal illness both in cholera endemic areas and in areas where cholera was not considered to be a health problem had been widely reported by Dakin *et al.* (1974).

Massad and Oliver (1987) reported that thiosulphate-citrate-bile salts-sucrose agar had been routinely used for the isolation of *V. cholerae* and also suggested that the medium offered significant potential as a selective and differential medium for *V. cholerae*.

Morris *et al.* (1995) suggested with regard to clinical presentation and general modes of transmission that serogroup O139 does not differ from O1, but the shifting predominance of *V. cholerae* O1 El Tor and O139 Bengal as the etiologic agent of cholera suggested that aquatic populations were dynamic, a factor that their research explored.

Xu *et al.* (1983) reported that *V. cholerae* could survive in the estuarine and marine environment in a viable, but non-recoverable stage and this also opened new opportunities for understanding the ecological role of this organism. The study also revealed that the survival might be dependent on several factors, such as the occurrence of particular physico-chemical conditions, a specific association of the bacteria with aquatic plants or animals and or the existence of specific ecological associations involving several components of the aquatic environment.

Colwell and Huq (1994) researched across many disciplines providing a composite model of transmission, demonstrating how the cycling of *V. cholerae* between aquatic and human environments may be significant in epidemic cholera. Such a model can provide a mechanism for viewing physico-chemical parameters and
epibiotic interactions with plankton that involve *V. cholerae* in the aquatic environment as an agent of disease.

Laboratory microcosm study on *V. cholerae* conducted by Huq *et al.* (1984) on the influence of water temperature, salinity, and pH on the multiplication of toxigenic *V. cholerae* serovar O1 cells, revealed their attachment to live planktonic crustaceans. Heidelberg *et al.* (2000) reported that *V. cholerae* strongly influenced nutrient cycling in the marine environment. The seasonal factors, such as rainfall and hours of sunlight contributed directly to the physical and chemical characteristics of water that, in turn, affected plankton populations was described by MacDonell *et al.* (1984). Ostling *et al.* (1993) reported that *V. cholerae* showed a set of physiological and biotic adaptations to adverse environmental conditions, such as size reduction, metabolic rate increase, and attachment to substrates.

Saksena *et al.* (2005) reported that the known 5-(methoxycarbonyl) pentyl α-glycoside of the hexasaccharide of *V. cholerae* O1, serotype Ogawa was newly prepared. The efficiency of construction of the hexasaccharide from the disaccharide glycosyl acceptor and each of the two tetrasaccharide glycosyl donors as an alternative to the intermediate coupling of the disaccharide glycosyl donor was evaluated.

Soomro and Junejo (2004) reported that the emergence of cholera had been a significant public health problem around the world and the study also revealed the battle to completely control the deadly disease whereas multiple environmental factors were considered to be the aetiological relationship, as no single source was found to host the microorganisms in an inter-epidemic period. Siddique *et al.* (1996) detected substantial differences in *V. cholerae* redistribution, appearing nearly two
years after the initial spread of serogroup O139 in Bangladesh and in coastal regions
*V. cholerae* O1 El Tor re-emerged and coexisted with O139, but a new clone of *V. cholerae* O1 El Tor replaced O139 in the northern districts. Therefore, conditions, i.e., temperature, salinity, biotic interactions, experienced by *V. cholerae* O1 and O139 in the aquatic environment, combined with immunity and possible co-infections occurring in humans, may influence emergence and resurgence by altering regional persistence of clones, genetic reassortment, abundance, and pathogenicity.

Sack *et al.* (2003) pointed out that the prevalence of *V. cholerae* in the environment was a constant threat to human beings due to its reemergence/resurgence in some parts of the world with special reference to Asian countries like Bangladesh, India and Pakistan. Morris (2003) described that *V. cholerae* could thrive best in marine water throughout the world, encompassing USA, Russian states, Spain, Europe, Japan, Asia and Australia. The contaminated water with free-living *V. cholerae* cells were probably the main origin of epidemics, followed to a lesser extent by contaminated food especially in seafood products like oysters, crabs, and shellfish was described by Kaysner and Hill, 1994 and Donovan and Netten, 1995.

Dastidar *et al.* (1977) strongly reported that, of 124 strains of *V. cholerae*, 32 multiply resistant to antibiotics and that resistance appeared to be determined by R plasmids on the basis of their effective elimination by sodium dodecyl sulfate, acridine orange, ethidium bromide, and ultraviolet radiation.

Lino and Deogracious (2005) reported that the preparations from plants were the original therapeutic interventions used by man to control diseases in humans and livestock. This study also revealed that nearly all cultures from ancient times to the present day have used plants as a source of medicines. Vines (2004) reported that
more than 80% of the world’s population in developing countries depended primarily on herbal medicine for basic healthcare needs, which was estimated from World Health Organization. Sengun and Karapinar (2004) reported that treatment with lemon juice was most effective in eliminating viable *Salmonella typhimurium* cells than treatment with vinegar.

Beuchat (1994) and Sofos et al. (1998) in their experiment showed relatively low antimicrobial activity of herbal decoctions due to insolubility of the essential oil components which were known to inhibit the growth of yeasts and a wide range of bacteria, and the study also suggested that it might well be attributed to the high antibacterial activity exhibited by the leaf decoctions. Jamila Patterson et al. (1994) reported that the *Chicoreus* meat was delicious and proteinaceous and the demand for this gastropod had increased considerably. The study also revealed that, the meat got contaminated to a large extent due to the unhygienic practices followed by the local fisher folks. Softening of *C. ramosus* meat after cooked under pressure and treated with locally available herbal decoctions and synthetic chemicals showed no adverse effect on *C. ramosus* meat was described by Xavier Ramesh and Ayyakannu (1994). The antimicrobial food preservatives might be added to assist in inactivating viable pathogens or preventing growth of contaminating pathogens during processing stage and subsequent storage period was described by Barnes and Impey (1968) and Thongson et al. (2004). Davidson and Naidu (2000) showed much interest on utilization of plant-derived compounds as antimicrobials in foods. The use of herbal medicines in developed countries was also growing and the study of Canter et al. (2005) had reported that 25% of the UK population took herbal medicines regularly.
As researchers identify and isolate the bioactive components, our understanding of their physiological, therapeutic, and clinical actions increased.

Ottaviani et al. (2001) showed that various antimicrobials were effective in vitro against the NCVs, some against all isolates and others having a strain or species-specific activity. Zanetti et al. (2001) suggested that Vibrio sp. should be monitored carefully to detect those with antibiotic resistance potential and to determine the possible mechanism of transfer of the genes responsible to more pathogenic vibrios such as V. cholerae. Mudryk (2005) revealed that a high level of antibiotic resistance in marine bacteria might result from terrestrial bacteria with antibiotic resistant plasmids entering the seawater and this fact might be responsible for the observed prevalence of resistant genes in the marine environment.

Dupont et al. (1985) stated that the persistence of V. cholerae, biotype El Tor, in a patient treated with trimethoprim-sulfamethoxazole was due to the acquisition of a conjugative resistance plasmid and the plasmid, with a molecular size of 72 megadaltons, belonged to incompatibility group 6-C and conferred resistance to ampicillin, chloramphenicol, sulfonamide, and trimethoprim.

The emergence and maintenance of bacteria resistant to antibiotics were mainly brought about by the incorrect utilization of drugs was described by Anderson (1968). Sahoo and Mukherjee (1997) suggested that antimicrobial chemotherapy was essential in controlling epizootic. Shome and Shome (1999) reported that bacteria pathogenic to humans might occur naturally in farmed fish or aquatic environment and made their way to humans with spread of resistance genes, leading to health problems.
The maintenance of a high standard of environmental sanitation and mass chemoprophylaxis with doxycycline controlled outbreak of cholera as reported by Goh et al. (1990). Baquero et al. (1998) reported that the increased use of antibiotics in health care, as well as in agriculture and animal husbandry, was in turn contributing to the growing problem of antibiotic resistant bacteria. Products such as antibiotics, disinfectants, sterilants and heavy metals used in industry and in household products creates a selective pressure in the environment that leads to the mutations in microorganisms that will allow them better to survive and multiply.

Ramamurthy et al. (2000) described that multidrug resistance in \textit{V. cholerae} was common and resistance profiles changed with time, making susceptibility surveillance imperative to determine effective therapy. Hsu et al. (1992) reported that differences in the percentage of bacteria resistant to various antibiotics might reflect the antibiotic application and hence serve as its indicator. Rabbani et al. (1989) reported that the antimicrobial agents, including tetracycline, are effective in reducing the volume of fluid loss and the duration of diarrheal illness. The occurrence of antibiotic-resistant bacteria increased in aquatic environments with the emergence of bacteria resistant to antibiotics was described by Schwartz et al. (2003). Miyazato et al. (2004) reported that the analysis of antibiotic resistance determinants on plasmids and interferon were used as an epidemiological tool. The susceptibility of bacteria to antibiotics was not static as reported by Obi et al. (1998) and resistance might be due to antibiotic abuse, antibiotic overuse, chromosomally or plasmid mediated.

Falbo et al. (1999) reported that the multidrug-resistant \textit{V. cholerae} O1 El Tor strains isolated during the 1994 outbreak of cholera in Albania and Italy were characterized for the molecular basis of antibiotic resistance and all strains were
found to be resistant to tetracycline, streptomycin, spectinomycin, trimethoprim, sulfathiazole, and the vibriostatic compound O/129 (2,4-diamino-6,7-diisopropylteridine).

Rabbani and Greenough (1999) suggested that, to reduce the risk of food-borne transmission of cholera, it was recommended that foods should be prepared, served, and eaten in an hygienic environment, free from faecal contamination and proper cooking, storing, and re-heating of foods before eating, and hand-washing with safe water before eating and after defaecation were important safety measures for preventing food-borne transmission of cholera.

Udden (1914) showed that the hydrodynamic conditions prevailed during deposition of sediments, controlled the size and composition of the sediments. The grain size distributions were mixtures of two or more component distributions or populations and the study reported by Doeglas (1946) also revealed that varying transport conditions produced these distributions. The degree of sorting was dependent on the size of the sediments and served as a measure to decipher the energy or the depositional environment and to know the presence or absence of coarse and fine-grained fractions was described by Mckinney and Friedman (1970).

Angusamy et al. (1998) showed that in Tuticorin a high-energy environment was indicated by strong convergence in the north as well as south of spit formation. This result also revealed the poorly sorted nature of few samples that indicated the incapability of the hydrodynamic processes. Passega (1957) reported that the percentile grain size against median size obtained specific patterns characteristic of the sediment deposition, which was helpful to delineate the character of sediment deposition.
The fish and shellfish contaminated by sewage or other environmental sources of *V. cholerae* and several *Vibrio* sp. formed the part of the natural environment was described by Vanderzant *et al.* (1971). Jay (1978) showed that the flesh of live healthy fish was usually sterile but bacteria were found in the gut as well as on the skin, including the gills. DePaola *et al.* (2003) reported about disease outbreaks associated with shellfish consumption. Rabbani and Greenough (1999) reported that fishes were likely to be contaminated by *V. cholerae* when the surrounding water was contaminated by sewage or other environmental sources. The study also revealed that the molluscs, crustaceans, crabs and oysters, which feed on plankton, could become infected with *V. cholerae*.

Gopal *et al.* (2005) reported the occurrence of various *Vibrio* species in water, sediment and shrimp samples from multiple shrimp farm environments from the east and west coast of India. Fuenzalida *et al.* (2006) described that large epidemics of diarrhea associated with raw seafood consumption occurred during summers of 2004 and 2005 in the environs of Puerto Montt and its surroundings in southern Chile.

West and Lee (1982) described that temperature appeared to be the most important factor controlling the densities of *V. cholerae* with uniformly high counts during the summer and a noticeable decline in the winters. Patterson (2002) reported that the domestic sewage exacerbate the problems caused by industrial effluents to the coastal ecosystem. The perception that microbes are homogeneously distributed in seawater was changing to a perception that microbes were distributed heterogeneously was reported by Azam (1998).

DePaola (1981) described that once infected, particularly clams and oysters could harbour *V. cholerae* for weeks, even if refrigerated and also researched that in
crabs, the organisms could rapidly multiply at ambient temperature, and boiling for less than 10 minutes or steaming for less than 30 minutes does not completely kill *V. cholerae*.

Felsenfeld (1967) reported that *V. cholerae* O1 could survive for more than two weeks in different dairy products, including milk, milk products, soft deserts, and cakes. He also reported that addition of sugar and eggs enhanced bacterial survival and although *V. cholerae* were killed by pasteurization of milk, the organisms could persist in raw milk as long as four weeks, even if refrigerated.

It has been shown that *V. cholerae* could live and grow on cooked chicken, and an increase in numbers of *V. cholerae* from 103 to 106 within 16 hours has been demonstrated by Kolvin and Roberts (1982). Contamination of meat of animal origin occurred exogenously during processing, cooking, storage, or consumption.

Ramaiah *et al.* (1996) described that the numerical abundance of viable heterotrophic bacteria in Tuticorin was within the ranges reported earlier from Southeast coast of India and variations in numbers of heterotrophic bacteria were common within a location and even within a single sample was reported by Ramaiah and Chandramohan (1987) and further, plate counts considerably underestimate total bacterial numbers were stated by Hoch and Kirchman (1993).

Shriadah and Ghais (1999) described that higher concentration of nitrate in Sharjah waters were due to the highest rate of nitrate regenerations from organic materials and Zooplankton excretion. Subramanian and Mahadevan (1999) reported that the prevalence of trace metals in open coastal water was affected by several factors such as land drainage flocculation, incorporation into phytoplankton and adsorption/desorption from suspended matter. Hood and Winter (1997) described that
*V. cholerae* exhibited the general pattern of attachments with optimum rates at temperature and salinities typical to semi-tropical and tropical estuarine and marine environments.

In the aquatic environment, the distribution and population of *V. cholerae* controlled by major environmental parameter like water temperature was described by West and Lee (1984). Colwell and Huq (1994) described that the strains of toxigenic *V. cholerae* were widely distributed in freshwater, estuarine, and marine environments, and the organism was able to survive estuarine conditions.

An early observation by Seligmann (1918) indicated that consumption of improperly cooked horse meat was incriminated in a food as a vehicle of transmission of cholera outbreak in Berlin in 1918. The meat had been prepared by an infected butcher who succumbed to cholera the next day. *V. cholerae* could survive on cooked rice, potatoes, eggs, and pasta for up to 5 days, and could also survive in spices, including pepper and cinnamon, for up to several days, was reported by Pan American Health Organization (1991).

Colwell *et al.* (1990) reported that fish becomes infected with *V. cholerae* either due to sewage contamination of water or by ingestion of aquatic vegetation and zooplankton infested with *V. cholerae*. Wong *et al.* (1992) stated that in a food survey in Taiwan, 1088 vibrios, including *V. cholerae* and other species, were isolated from seafoods and aquacultured foods. In many countries, fish eaten raw or undercooked was reported by Klontz *et al.* (1987). Outbreaks of cholera due to consumption of raw fish have been reported from Japan as early as 1886 by Donitz (1892) and from the Philippines in 1908 by Heiser (1908).
Pandit and Hora (1951) observed that, in India, the transmission of endemic cholera is maintained through infection of *hilsa* fish, which breeds abundantly in the Hoogly River that runs through Calcutta. Fish may serve as an important vehicle of transmission of cholera in the endemic areas of Asia, where it is a major food item and is likely to be contaminated by *V. cholerae* due to both poor environmental sanitation and poverty prevailing in this region.

Valdes and Real (1998) reported that high concentration of inorganic phosphate were due to the monsoonal flow of fresh water and land run-off which could support the *Vibrio* population. Ramaiah and Chandramohan (1987) showed that variations in numbers of heterotrophic bacteria were common within a location and even within a single sample and further the plate counts considerably underestimated the total bacterial population.

Kaper *et al.* (1995) reported that there was a long history of scientific accomplishments resulting from the study of cholera and *V. cholerae*. The scientific legacy was notable not only for the observations related specifically to cholera but also for the numerous contributions to other fields of medicine. The proposition by Snow (1855), after analyzing cholera attack rated in relation to source of household water supply in London in the mid 19th century that transmission of this disease was related to water source constituted an early landmark in epidemiology.