



Mini Review

Plant derived Extracts and Respective Compounds against major Life-Threatening Water contaminant Bacteria *Vibrio cholerae*: A comprehensive Mini Review

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Abstract

Cholera, caused by a gram negative anaerobe Vibrio cholerae, is one of the most ancient and major water borne human health concerns demanding thousands of lives every year all around the world, Asia and Africa being at the top and America being a recent victim. A number of interventions have already been formulated so far and few are under extensive research and scrutinization. Certain serious limitations of the strategies have eventually led to designing highly efficient prevention measures. This review chiefly focuses on the natural or plant derived products used as anti-Vibrio agents, for instance, catechin present in blackberry, tea, magnolol present in magnolia species plants and so on. This review also promotes the idea of using these plant derived materials in treating drinking water contaminated with cholera pathogen. Hopefully, this approach will certainly be able to eradicate the pathogen from water, in turn eradicating the diseases from occurring as well as from spreading.

Keywords: Cholera, *Vibrio cholerae*, plant derived products, prevention.

Introduction

It's been almost a couple of centuries, as depicted by modern history; our world is under severe threat of several water borne bacterial diseases, cholera is one of those major concerns. Though the history of cholera can be traced back into the era of Gautam Budhha or Hippocrates, its 1817 when the first pandemic of cholera was documented¹. Cholera is a serious life threatening complication of human caused by the bacterium *Vibrio cholerae*, a gram negative facultative rod shaped anaerobe. The bacterium invades the human body via ingestion of contaminated water and food, usually by fecal materials, and resides in human gut, attached by a toxin co regulated pili (TCP produced by *tcp* gene of *V. cholerae*). Upon attachment, it exerts its effect by producing multi subunit cholera toxin which in turn results in water and salt loss from the body. If the complication is untreated, this drastic fluid loss can lead to severe dehydration and finally death².

Considering the period of 2000-2013, there are millions of cases reported to WHO from around 45-58 number of countries chiefly belonging to the Africa and Asia. The other three continents persistently have shown very less number of cases and death. The only exception is the statistics of 2010-2013 in America where morbidity and mortality rate were even higher than Africa and Asia³⁻¹⁶ figure 1a and 1b.

Over a century or so, several intervention strategies have been formulated to combat cholera. Oral Rehydration therapy (ORT)

is the most widely used and accepted among those. Except the ORT, there are other therapies such as antimicrobial therapy, bacteriophage based biocontrol, vaccination strategy, Reccadotril etc. Besides these well studied therapies there are other few approaches to treat cholera are under vigorous research and scrutiny such as use of small molecules e.g. Toxtazin. Unfortunately and inevitably all the cholera combating methods exist with certain severe limitations which, at times overshadow the efficacies of these treatments. Availability of clean water to prepare oral rehydration solution is one of the most important limitations of ORT, emergence of antimicrobial strains is the factor limiting the use of antibiotics, expense and formulation of universal vaccine applicable in any parameter and settings limits vaccination etc.

Major physical, chemical methods of *Vibrio* removal and their limitations

Considering the serious limitations of these treatments strategies it can be undoubtedly stated that there is an urgency of formulating a full proof prevention technique. There have been a number of researches conducted in past as well as in recent times among which many are currently well recommended by the health organizations. Following are the major strategies among those:

Boiling of water to be consumed is an effective option to remove the bacterial pathogens. Enormous amount of heat kills

the bacterial cells by affecting the proteins, lipids in the cell membrane which are most essential components a cell requires for its survival. This event eventually kills the bacteria. The same strategy has been suggested in case of the preventing cholera. Most of the suggestions recommend to boil the drinking water at the point of use level as an alternative to another efficient method of disinfecting water i.e. chlorination. Boiling can also be used in addition to chlorination or adding lime to the water as well as along with the filtration which has shown to be efficient in removing *Vibrio cholerae*. Usually the recommended time for boiling is one minute¹⁷. Certain workers suggest boiling any water that is doubted not safe to drink. Supplementing ORS along with the boiling treatment of water have shown to save lives.

Though boiling water is one of the most ancient techniques for disinfecting boiling water, still there are some issues limiting the use of this. Firstly, the change of taste is unacceptable for a few, secondly the water must not be cooled, and otherwise it can get

contaminated again. One more reason is the lack of knowledge of using this very method of disinfection. For instance, in Liberia, it was found that only 31% of the people knew the reason for boiling the water and consuming it. Besides this, traditional culture also plays an important role where the people are not ready to accept that drinking water needs any kind of external aids to become consumable. Hence from this point of view, an education or awareness regarding this issue must be provided. Finally, the chief limiting issue of boiling is the expense of fuel¹⁸.

Chlorination is one of the ancient and effective methods of disinfecting water, precisely to render it microorganism free. The use of chlorination, at least the use of it can be traced back in 1900 century eve, when studies recommended the use of chlorine and its compounds for making the water germ-free. Since then, till now chlorination is being used for the disinfection of the water.

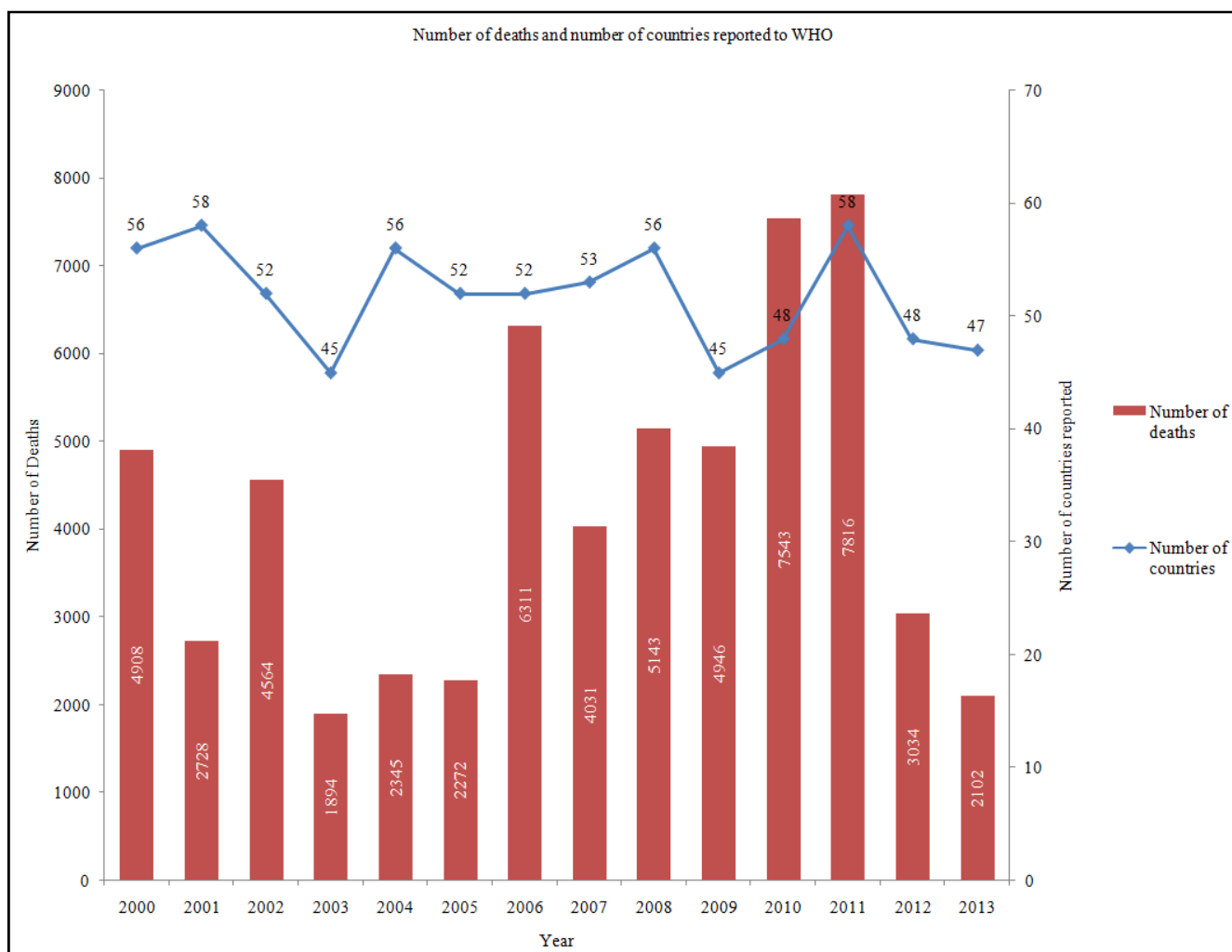


Figure-1(a)

Number of countries reported cholera cases and number of death reported to World Health Organization (WHO) with in a period of 2000-2013

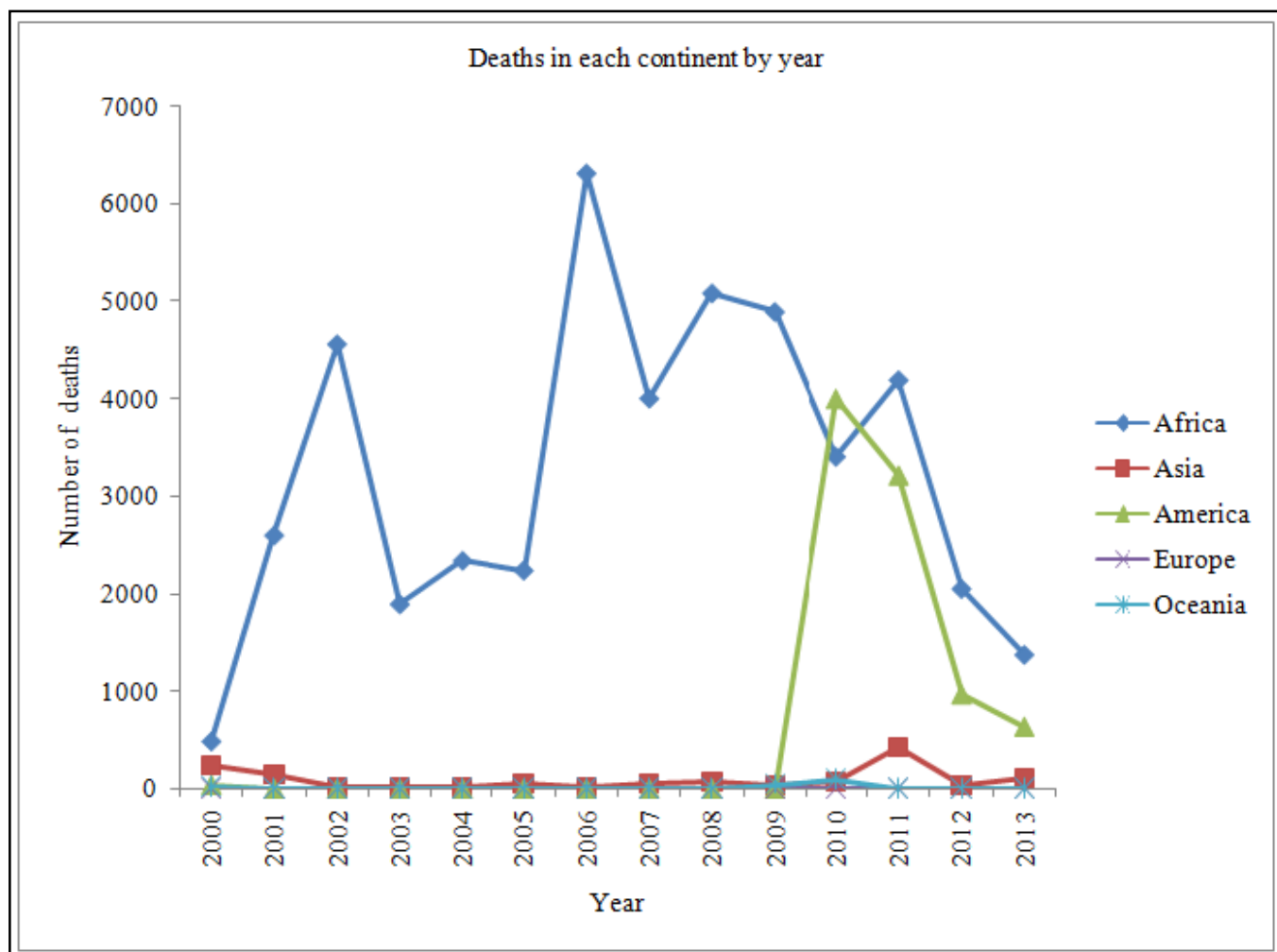


Figure-1(b)
 Number of deaths occurred due to cholera in each continent within the period of 2000-2013.³⁻¹⁶

It's only the sixth pandemic of cholera, since when chlorination is being used as a first line method for treating water with *Vibrio cholerae*. In 2001, a study conducted by Sousa et al, suggested the most effective dose of chlorine of 8 ppm to kill the *Vibrio* in pure cultures¹⁹. According to Thampuran et al, 2ppm of chlorine was found to be effective against 10³ cfu of bacteria/ml in 10 minutes²⁰. Possible cascade of chlorine action is to disrupt the cell wall by reacting the chlorine with cell surface target sites releasing the vital cellular materials ultimately resulting in the termination of the membrane associated functions and cell death. The main advantages of chlorination is the effectiveness against wide range of microorganisms, less expensive compared to UV treatment or ozone disinfection, easy handling, storage, shipping and absence of toxic residual in ideal situation. 10% solution of household bleach can be used in order to disinfect drinking water. For lesser amount of water a drop of bleaching solution can be added to kill the germs. For larger amount of water 5ml of bleaching solution can be used. The bleach and the water should be mixed thoroughly and should be kept overnight before drinking.

In spite of being an effective, widely used method, chlorination has certain set off disadvantages. The residual chlorine, though non-toxic but can be threatening for aquatic system and might require dechlorination which is in turn is an expensive method to treat water, moreover, the effect of long term dechlorinated discharges are yet to be determined. Another drawback is the corrosiveness of chlorine and its compounds²¹. Though the use of chlorine is an easy method to perform but it can pose a risk during shipping, storing etc. The indirect effect of chlorination on human health is the conversion of certain organic compound in water to hazardous materials. Besides these, presence of certain chemicals in water such as ammonia, can give rise to toxic chemicals and thus limiting the use of chlorination for this kind of water²². Emergence of chlorination resistant rugose form of *Vibrio cholerae* also have been reported which can be considered as an important concern regarding the efficiency of chlorination against cholera²³.

Filtration is one of the techniques that can be used primarily to eliminate the germs. Once the solid suspended macro-materials

are eliminated by settling, filtration can be done clean fabric, sand or charcoal filter. Numbers of studies have been done to formulate simple, cost effective as well as efficient filtration method. Among these candle filters, stone filters, sand filters are used²⁴. Specifically for *Vibrio cholerae* slow sand filtration is being used for efficient filtration. The most recent prevention or filtration technique is significantly simple and inexpensive i.e. Sari or cloth material. Haq et al in 1996 and Colwell et al in 2003 in Bangladesh studied the filtration efficiency of old sari material folded four or eight times. This simple sari filtration strategy was found to be able to remove more than 90% of the bacteria^{25, 26, 27}, though this method is not able remove individual bacteria or viruses. The primary limitation is that this particular method can't be used alone for successful disinfection of water, which means, there should be some other method working along with filtration for proper disinfection. Along with this, filtration method doesn't assure the no-risk of contamination during storage after filtration.

UV treatment: In the end of 19th century Johann Wilhelm Ritter discovered the invisible ray just beyond the violet region of electromagnetic spectrum with a wavelength range of 10-400nm and it took another half a century to discover the antimicrobial activity of the ray by Dr. Arthur Downes and Thomas Porter Blunt²⁸. There have been number of investigators to confirm this finding afterwards which made this a standard method for disinfection of water. Treating drinking water in order to get rid of pathogenic bacteria such as *E. coli*, Salmonella, Vibrio, is widely used commercially now a days. UV rays basically targets the genetic material eventually arresting the growth of the organism which subsequently results in death.

Even though UV treatment of water is highly effective, easy-to-use and widely used method, still this strategy has got certain set of disadvantages. First limitation is its dosage as low amount of UV may not be effective in killing all the germs, in certain occasions organism can repair its genetic material and revert back into its infective form, though a study in 1981 showed the inefficiency of *Vibrio cholerae* to repair its genetic material due to the lack of dark repair system²⁹. UV treatment is not cost effective like chlorination and it also can be affected by the presence of suspended and dissolved solids. Besides these, other chemicals such as ammonia, nitrite, hardness, pH can also affect the effectiveness of this method. Other limitation of UV treatment is that it gives only point disinfection and doesn't give any residual germicidal effect. UV treatment also doesn't remove the bacterial cells from the water stream but it converts it into pyrogens. There are bacterial pigments which can give primary protection from UV light such as melanin, scytonemin, prodigiosin etc³⁰.

Solar disinfection has also been used for disinfection of

drinking water which showed considerable reduction in the cholera and diarrheal episodes^{31, 32} but even this effective method is of less applicability when the volume of water to be disinfected is large and also time consuming³³.

Plants and their extracted products with Anti Vibrio activity

Though the already mentioned prevention techniques are well studied and efficient, still those are also not fully preventive hence there is a need of some other intervention methods which will be less expensive than the treatment strategies and simpler and more efficient than the conventional preventive measures. It's been centuries since natural products are being used as remedies to life-threatening complications. Few of those are in practice even today when non-natural medicines have made a remarkable advancement. But, particularly in the context of cholera, current era is a period when synthetic medicines are facing certain serious limitations which is promoting the use of natural remedies in turn. Mostly to replace the use of antibiotics which is the most efficient intervention in killing the organism, use of natural products have been promoted because of the emergence of antibiotic resistant strains. In last half a century there have been many research articles published based on the antimicrobial, more precisely AntiVibrio effect of plant products.

Starting from 1990's, a study demonstrated the efficiency of *Feronia limonia* leaves against *Vibrio cholerae*³⁴. Another plant named *Terminalia macroptera* was also reported to be highly efficient in killing the bacteria *Vibrio cholerae*. The active fraction was found to be ellagitannins, hydrolysable tannin³⁵. A study in Peru in 1994 tested 14 plant samples to determine their in vitro effect on *Vibrio cholerae*, where only Tea infusion and decoction of *Punica granatum* peel showed the best bactericidal efficacy and was suggested it as a potent candidate for combating this particular bacterial infection³⁶. In 1997, another study reported high anti Vibrio activity of methanol, water and acetone extract of the plant *Helianthemum glomeratum*. The highest active extracts were from stem and the leaves of this particular plant. The same plant was also found to be active against Shigella, another deadly enteropathogen³⁷.

A pocketful number of studies have been conducted in the current century of 21st dealing with the plant products against this deadly pathogen. To start chronologically according to the year, an experiment conducted in 2002, showed anti cholera toxin effect of apple polyphenolic extract (APE) against the activity of cholera toxin. In this study it was found that the non catechin polyphenols had no significant efficiency in limiting the activity of the toxin which in turn indicating the efficacy of catechin again likewise the study conducted by many investigators afterwards such as Toda et al³⁸.

In 2004, an experiment done by Taguri and Colleagues demonstrated anti *Vibrio* effect of ten different plant polyphenolic compounds. The polyphenols used in this particular study were epigallocatechin, epigallocatechin -3-O-gallate isolated from green tea, punicalagin, tannic acid, castalagin, prodelphinidin, geraniin, loquat procyanidin, theaflavin and loquat treated green tea polyphenols. All the counts showed anti *Vibrio* activity to different extent with a mean minimum inhibitory concentration of $162 \pm 165 \mu\text{g/ml}$ which was lowest among the other entire organism tested in the same study depicting a well susceptibility of *Vibrio* against these natural chemicals. Specifically, tea catechin showed more efficiency against Gram +ve bacteria probably because of negatively charged cell wall of the gram negative bacteria repelling the negatively charged catechin molecule. This particular study gives a wide and generic idea of using the plant extract materials against *Vibrio cholerae* as well as the other species³⁹. Not only were the polyphenolic compounds, essential oils extracted from plants also found to be efficient. Acevedo et al in 2005 found essential oil extracted from the plant *Lepechinia caulescens* to be highly active against *Vibrio cholerae* with a MIC of only $4\mu\text{l/ml}$ and the chief components responsible for this activity were found to be borneol, camphor and trans-caryophyllene⁴⁰.

Stinking passion flower, an exotic medicinal vine demonstrated remarkable anti *Vibrio* efficacy when the leaves ethanol and acetone extraction were tested on *Vibrio* and other bacterial pathogen suggesting it to be a significant agent to be used against diarrheal pathogens such as *Vibrio cholerae*.⁴¹ In the same year, *Allium sativum*, *Camellia sinensis* and *Chamaesyce hirta* showed significant power of killing *Vibrio* with a minimum bactericidal concentration of $< 100\mu\text{g/ml}$ ⁴². Neem extract's anti *Vibrio* efficiency was determined by Thakurta and his colleagues in a study where the neem extract was administered orally in mouse infected with *Vibrio cholera* O1, O139, nonO1 and non-O139⁴³. Along with other plant materials neem efficiency was confirmed in 2010, a study conducted in Amity University, India by Mehrotra et al, who demonstrated the efficiency of few medicinal plants such as neem, amla, Assam tea and clove ethanolic extract against *Vibrio cholerae* where all the plant extracts showed fairly high activity against the organism. Among these amla pulp and clove bud showed a significantly lower MIC ($0.025 \mu\text{g/ml}$) value indicating high susceptibility of *Vibrio cholerae* against these materials⁴⁴.

A recent study in 2009, done by Acharyya et al demonstrated the anti-*Vibrio* efficiency of nine different ethnobotanically selected plants on *Vibrio cholera* O1, O139 and non O1-O139. The study reported Vibriocidal capability of all the methanol extracts on at least one type of bacteria. Among the nine medicinal plants *T. Cebula* and *S. Cumini* showed inhibition against all the strains of *Vibrio cholerae* and were suggested to

be a promising candidate against cholera in future⁴⁵. In the same year, an in vitro investigation of anti-*Vibrio* activity of acetone extract of *Saraca indica linn* and *Datura stramonium* and aqueous extract of *Allium sativum linn* showed significant efficiency against standard strains of *Vibrio cholerae*, *Vibrio parahemolyticus* and other multi drug resistant strains with an MIC value ranging from 2.5-15 mg/ml. Further analysis of the crude extract revealed the active agents were tannin, scopolamine, atropine and allicin. Hence these plant candidates also can be studied and used further for combating *Vibrio cholerae* and thus cholera⁴⁶.

Sanchez et al studied the Vibriocidal effect of 27 different plant extracts using aqueous, ethanol and methanol extraction on to different strains of *Vibrio cholerae* i.e. 1837 and 569-B, where most of the aqueous extraction showed lack of inhibition whereas methanol extraction showed maximum of the same. In particular, methanol extraction of Sweet acacia had the best efficacy with an inhibition zone of 2.7 ± 0.3 cm. Fruits on pineapple and mango showed vibriocidal capability in all the extraction methods and on both the strains. The authors suggested the use and further study on sweet acacia, white sagebrush, basil and nopal cactus as these plants showed a considerable anti-*Vibrio* efficiency⁴⁷.

Capsaicin (N- anillyl-8-methyl-nonenamide) extracted from red chilli was also found to be effective against *Vibrio cholerae* and cholera toxin. It was shown by Yamasaki et al than methanol extracted capsaicin can inhibit the cholera toxin production by about 90%, depicted in table-1. It could also reduce transcription of the gene *ctxA* by 43%, the toxin component, *tcpA* and *toxT*, the other virulence associated factors⁴⁸. White pepper and Sweet fennel also can inhibit the CT production comparable to capsaicin when extracted with 90% methanol.

Table-1
Effect of Capsaicin on Cholera toxin production of different strains of *Vibrio cholera*

Effect of capsaicin	Strain	Reduction in CT production
	E1 Tor	70-99%
	E1 Tor variant	90-99%
	Classical	78-90%
	O139	85-95%
	CT producing nonO1/O139	90-95%

A recent study performed by Shamsuddin et al in 2013, where ten different mangrove plants were selected and methanol and aqueous extracts of leaves were tested on six different *Vibrio* species other than *cholerae*. Among these ten leaf extracts only *Sonneratia caseolaris* methanolic extract showed significant anti *Vibrio* activity and was suggested to be used against *Vibrio*

pathogens in aquacultures⁴⁹. Another study in the same year attempted to show the anti-Vibrio activity of herbal decoctions where the investigators selected 45 plant samples primarily and among those only thirteen potent medicinal plants were chosen to be used finally. In this particular study, *C. Ramosus* meat was used instead of conventional bacterial media. Among the thirteen, *Abrus precatorius*, *Aegle marmelos*, *Alpinia galangal*, *Cleom gynandra*, *Cordia obliquawillel*, *Moringa oleifera*, *Sida cordifolia* and *Tinospora cordifolia* were found to be most effective against the bacteria as these extracts were able to kill all the Vibrio cells in a period of 96hours, though other extracts also demonstrated some extent of efficiency against the organism.⁵⁰ A study conducted by Kouitcheu et al, published in 2013 only showed Vibriocidal activity of four different plant extracts. Among these extracts, methanolic extract of *Cassia arereh* and *Trichila emetica* demonstrated significant efficiency with MIC value of 12.207 and 97.656 µg/ml. When these plant extracts were administered in combination with antimicrobial agents the MIC value reduced considerably⁵¹. Five different plants, namely *Allium sativum*, *Coriandum sativum*, *Cuminum cyminum*, *Curcuma longa* and *Zingiber officinate* extracted in both alcohol and water were tested against the cultures of *Vibrio cholerae*, *Vibrio parahemolyticus* and *Vibrio harveyi*. The maximum zones of inhibition in all the three cultures were in the plates with alcohol extract of *Cuminum cyminum* proving it as a promising candidate for using against *Vibrio cholerae*⁵². Another plant named *Chromolaena odorata*, an invasive plant found in humid tropics was also found to be efficient in killing *Vibrio cholerae*. Dichloro methane extract and butanol extract of this plant leaves were analysed and sinensetin and scutellareintetramethyl ether were found to be the active compounds⁵³.

One of the most important and most well evaluated plant secondary metabolite is catechin present in green tea and blackberry plant in large amount. Several studies have been conducted to evaluate the Vibriocidal effect of catechin. Toda et al in 1990 reported the effect of (-) epigallocatechin, (-) epicatechin gallate, (-) epigallocatechin gallate on *Vibrio cholerae* classical Inaba and E1 Tor inaba strains. These compounds were able to restrict the growth of the bacteria.⁵⁴ Again in 1991, Toda and his colleagues demonstrated the effect of catechin isolated from green tea against *Vibrio cholerae* O1 and its fluid accumulation capability⁵⁵. Along with green teas, black tea was also found to be effective against *V. Cholerae* E1 Tor *ogawa*⁵⁶. In another study epigallocatechin gallate was found the most effective among the catechin polyphenols extracted from tea and the galloyl moiety was thought to be the main component in increasing the permeability of the cell membrane⁵⁷. The efficiency of catechin was showed by Kajiya et al to be dependent on the concentration of salt in the aqueous medium, electrical charge of the bacterial membrane. Catechin activity is higher in the medium with higher amount of salt. One

the most important finding was the effect of membrane electrical charge. The efficacy of catechin was higher in case of gram positive bacteria. The explanation was given as the gram negative bacteria possess a negatively charged cell wall and at the same time the catechin is also negatively charge, hence the charge repulsion limits the catechin binding the negatively charged cells and thus reduces the efficacy subsequently⁵⁸. In 1990, Ikigai et al showed anti haemolysin activity of catechin compounds and theaflavin against cholera toxin and determined that this activity was dependent on the number of galloyl groups in their structure⁵⁹. Green tea polyphenols were also found to be effective against other Vibrio species such as *Vibrio parahemolyticus*, *Vibrio harveyi* etc.

Along with the phenolic compounds two more new compounds that have been found to be effective in killing *Vibrio cholerae* is honokiol and magnolol which are natural and plant derived materials. Hence this recent study also suggests the use of these particular biochemical compounds against *V. cholerae*⁶⁰.

Considering these studies and the conclusions, it can be sated that, the research and study on the natural products as remedies, especially against the water borne bacterial pathogens are doing a great advancement though should be subjected to more intense research. Mostly the polyphenolic compounds extracted from the medicinal plants have been observed to show the highest amount of anti-Vibrio activities all over the world and therefore can be researched further for better efficiency.

Future aspects

Use of natural products as remedy is being practiced since long time. The practical application and the research works have been greatly neglected in case of formulating remedies against serious life threatening diseases due to the marketed, highly efficient non-natural medical interventions. As far as cholera is concerned, mainly emergence of antibiotic resistant Vibrio has rendered the study and application of natural product popular again. Based on the above studies and their discoveries, this particular domain of research can certainly be taken forward and can be directed towards treating contaminated drinking water at storage level or at individual level. Use of most efficient plant extracts, rich in producing polyphenols and other active compounds, as summarized in table-2, containing higher galloyl moieties, individually or in combination in different bacterial concentration, as well as formulating a simpler method for extracting the active components instead of expensive methanol or acetone extraction methods can be of high importance. Furthermore, simple and precise application of these products or the plants to treat drinking water contaminated with *Vibrio cholerae* can be useful to get rid of this lethal complication. The compound profiling of the treated drinking water and their effects on human, if any, should also be carefully researched.

Table-2
Plants and their extracts possessing vibriocidal activity and mode of action

Plant name	Compound	Activity	Organism	Reference
Tea, <i>Punica granatum</i>	-	Vibriocidal	<i>V. cholerae</i> O1	36
-	Catechin, epicatechin, epigallocatechin	Anti-hemolysin	<i>V. cholerae</i> O1	54, 59, 39
Red chilli	Capsaicin	Anti-CT toxin	<i>V. cholerae</i> E1 Tor, O139, O1.	48
Basil, Nopal cactus, Sweet acacia, white sagebrush	-	Decrease in pH and cell membrane hyperpolarisation	<i>V. cholerae</i> O1 Classical	47
<i>Terminalia tebula</i>	-	Anti-Vibrio	<i>V. cholerae</i> O1, O139, non-O1-O139	45
<i>Lepechinia caulescens</i>	Borneol, camphor, caryophyllene	Anti-Vibrio	<i>V. cholerae</i>	40
<i>Terminalia macroptera</i>		Anti-Vibrio	<i>V. cholerae</i>	35
<i>Azadirachta indica</i> (neem)	-	Anti-diarrhoea	<i>Vibrio cholerae</i> O1, O139, non O1- 139	43
<i>Helianthemum glomeratum</i>	polyphenols	Growth inhibition	<i>V. cholerae</i>	37
<i>Passiflora foetida</i>	polyphenols	AntiVibrio	<i>V. cholerae</i>	41
<i>S. caesularis</i>	-	Anti-Vibrio	<i>V. parahemolyticus</i>	49
<i>Feronia limonia</i>	-	Vibriocidal	<i>V. cholerae</i>	34
<i>Abrus precatorius</i> <i>Aegle marmelos</i> <i>Alpinia galanga</i> <i>Cleom gynandra</i> <i>Cordia obliquawillel</i> <i>Moringa oleifera</i> <i>Sida cordifolia</i> <i>Tinospora cordifolia</i>	-	Anti-Vibrio	<i>V. cholerae</i> O1 Inaba, Ogawa	50
<i>Brucea javanica</i>	-	Anti-Vibrio	<i>V. cholerae</i> O1 Inaba , Ogawa	62
<i>Ocimum sanctum</i>	-	Anti-Vibrio	<i>V. cholerae</i>	63
<i>Garcinia mangostana</i>	-	Anti-Vibrio	<i>V. cholerae</i>	64
<i>Camellia sinesis</i>	-	Anti-Vibrio	<i>V. cholerae</i> O1 E1 Tor Ogawa	56
Cumin	-	Anti-Vibrio	<i>V. cholerae</i> , <i>V. Parahemolyticus</i> , <i>V. harveyi</i>	52
<i>Saraca indica</i> <i>Datura stramonium</i> <i>Allium sativum</i>	-	Anti-Vibrio	<i>V. cholerae</i> O1, non-O1, <i>V. parahemolyticus</i>	46
Tea	Catechin	Anti-CT toxin	<i>V. cholerae</i> O1	55, 61
Tea	Polyphenols (mainly with galloyl moiety)	Anti-Vibrio and anti-CT toxin	<i>V. cholerae</i>	57
-	Honokiol, Magnolol	Anti-Vibrio	<i>V.cholerae</i> O1 E1 Tor Inaba	60

Conclusion

Natural remedies are being practiced may be since the eve of human civilization. Even in current era they are of immense importance. In context of cholera, capsaicin which is present in Red chilli in abundance, catechin, a polyphenolic compound

present in blackberry, tea etc. and many other plant products. Several other plant extracts can be studied further to be used. This particular review chiefly suggests the idea of treating drinking water with his kind of natural materials rather than treating a human being infected by the bacterium. It is of high probability to render the drinking water free from the deadly

pathogen, therefore reducing the onset of the disease as well as reducing the dependency on the treatment strategies which are yet to become cent percent protective. A regular intake of these compound containing plants have already been recommended by many researchers. Besides this, treating the water to be consumed with these natural products hopefully will certainly reduce the complicity of combating *Vibrio cholerae* and cholera.

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