# Elimination of lymphatic filariasis

Lymphatic filariasis is a vector-borne parasitic disease caused by the filarial parasites, *Wuchereia bancrofti*, *Brugia malayi* and *Brugia timori*. Globally, more than 1000 million people live in endemic areas and are at risk of being infected with the parasite. In India, there are approximately 21 million people with symptomatic filariasis and 27 million microfilariae carriers. The common manifestations of the disease are episodic attacks of lymphangitis, filarial fever, hydrocele (males) and elephantiasis or lymphodema, etc. In an endemic area, infection is introduced by mosquito bite, which lodges the infective larvae to the human host during its blood meal. The infective larvae develop into adult worms, live in lipid-rich environments of lymphatics/lymphnodes, mate and produce microfilariae over several years. Individuals having microfilariae mostly remain asymptomatic for years, with milder attacks of lymphangitis and hydrocele (in males only). These individuals or microfilariae carriers help in maintaining the transmission cycle going by providing microfilariae to mosquitoes, in which they develop to infective larvae. Majority of the people at risk of filariasis live in rural areas. Poor sanitary conditions associated with low socio-economic status of the community make the environment a proliferate breeding place for vector mosquitoes, which facilitate transmission.

Based on certain developments in filariasis research, in 1997 the World Health Assembly took a resolution calling for the elimination of lymphatic filariasis as a public health problem. This resolution leads to the initiation of a global programme to eliminate lymphatic filariasis (GPELF). The GPELF recommends for mass drug administration of single dose of diethyl carbamazine (DEC) yearly to those living in endemic areas. Though this drug has limited effect on adult filarial worm, it removes microfilariae from infected humans and thus deprives mosquitoes of the opportunity to pick up infection from the affected host and transmit to healthy individual. Thus it can break the transmission cycle, by preventing transmission. Though the microfilariae disappear from the circulation after even a single tablet of DEC, they reappear again as the adult female worm remains intact and goes on producing microfilariae. However, the fecundity period of the adult worm is about 5–6 years and an annual dose of DEC for 5–6 years, can certainly help in curtailing transmission. To achieve this, all individuals in the endemic area have to consume the drug simultaneously.

In spite of limited health budget, illiteracy, poor knowledge about the disease, non-compliance to the drug, etc., India has to give top priority for the elimination of lymphatic filariasis as 553 million of its people are at risk of infection.

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# Water-fixing/producing bacteria for combating freshwater scarcity

This is in response to the commentary by B. P. Radhakrishna[1] on man-made drought and the looming water crisis. Freshwater is indeed increasingly becoming a scarce commodity and source of conflicts and tensions between and within countries. Taking clues from thermophilic bacteria found growing under extremely hot hydrothermal vents and under desert conditions, we propose that such or similar organisms inhabiting the deserts may be meeting their water requirements by manufacturing their own water. Such free-living or rhizospheric water-fixing/producing organism(s) can be modified by biotechnological interventions for harvesting freshwater to combat water scarcity in the long run.

Water is the single most vital component of the earth that made possible for life to originate, evolve, flourish and reach the present forms that we have today. Earth is called a wet planet, as two-thirds of it is occupied by water. About 99.7% of the water found on the earth is in the oceans and seas, and is not available for human consumption. Rest of the 0.3% is freshwater and a good proportion (22.7%) of this is in the form of glaciers, ice caps, atmospheric moisture and groundwater. It is now predicted that the next war, if it happens, will be for water. In the next 25 years, countries like India and many others in Asia and Africa will be facing acute freshwater shortage.

We know that certain living organisms (both flora and fauna) grow and thrive well in sand dunes of deserts like Sahara, but certain thermophilic bacteria and some higher forms of life have also been located in the sand dunes. Bioproduction and conservation of water by desert organisms may perhaps be resorted to under extreme water stress conditions. Desert animals like emu and ostrich are able to regulate their body temperature and water requirement. Ostriches conserve water by reabsorption of a large part of the water coming from kidneys and a high degree of folding of the mucosal surface of the gut[2]. There is also a possibility that some forms of bacteria, similar to that of the ruminating bacteria resident in the gut of these animals, may be producing water. Ruminating bacteria present in the stomach of cattle help them to digest cellulose. Methane-forming bacteria in the stomach of cattle are capable of producing water. Methane-forming bacteria convert $CO_2$ and $H_2$ into methane and water, and methane is expelled out from the anus of the cattle. These bacteria have unique nickel tetrapyrrole similar to chlorophyll and other factors such as methanopterin and methanofuran and cofactors 420 and 430. Similarly, sulphur bacteria grow at very high temperatures (50–55°C) under anaerobic conditions and produce $H_2S$. They have hydrogenase enzymes which can also fix $CO_2$ in the presence of hydrogen into water under aerobic environment. Similarly, certain desert plants are known for their ability for water conservation and adaptation to drought conditions and xerophytic environment. Desert soil may be harbouring rhizosphere flora or some free-living thermophilic organisms capable of fixing water from hydrogen and oxygen available in the vicinity. Indeed, several members of saprophytic fungi growing abundantly on waste cellulosic materials and some algae secrete exogenous peroxidases, which can use $H_2O_2$ and release water[3–6].

A number of thermophilic isolates have been obtained from hydrothermal vents. Some of these bacteria have also been found as ecto and endo symbionts of invertebrates such as *Alvinella pompejana* and *Rimicaris exocula*, which are associated with hottest environment of the hydrothermal vents that represent the most ancient continuously inhabited ecosystems on earth[7–9]. For example, *A pompejana* is a tube-like annelid polychaete endemic to East Pacific Rise, inhabiting the hottest areas of deep hydrothermal vent chimneys. The harsh chimney environment is characterized by extreme temperature gradient of 350°C and high concentrations of hydrogen sulphide (>1 mM) and toxic heavy metals, predominantly Cu and Zn. Temperatures range from 70 to 80°C in these tube-like organisms, which can survive even under temperatures of 100°C[10]. One of the striking features of this organism is its obligate association with a highly diverse and dense assemblage of epibiotic microorganisms. Rod-shaped, prostecate, spirally curved, filamentous, sheathed or unsheathed bacteria are scattered on the surface of the worm's integument, whereas clump-like assemblages of rod-shaped coccoid and filamentous bacteria are associated with cuticular protrusions in their intersegmental spaces[11]. Some of these bacterial associations are reported to be exhibiting remarkable resistance to heavy metals such as As, Cd, Ag and Zn and abnormally high levels of Cu. Some bacteria found in these symbiotic associations are *Acetobactor*, *Alteromonas*, *Pseudomonas* and *Vibrio*[7]. However, till date many of these dominant morpho types have eluded culturing in the laboratory. 16S rRNA has been used for their phylogenetic characterization. Members of protobacteria such as *Thiovulum*, a sulphide-dependent marine bacterium, have been found to be associated with *Rimicaris*[12]. Therefore, it is not off the point to expect some unknown forms of protobacteria like aquificales or even cyanobacteria/mycorrhizae and other fungi in symbiotic relationship. Unicellular and filamentous cyanobacteria have been noticed in 3500 million-year-old sedimentary rocks and endolythic forms have been noticed in 500 million-year-old rocks. Some life forms have been seen even in under-sea volcanoes[7,9].

Discovery of these terrestrial and deep-sea hydrothermal vents with temperatures of 375°C or above, and diversity of microbial communities growing in these hot niches rich in iron and sulphur have indeed thrown light on the processes of origin of life itself. These niches offer an environment similar to the primitive primordial earth, where life originated on this planet millions of years ago. Life is thought to have evolved in a similar highly reduced atmosphere provided by pyrites with hydrogen as a by-product. The pyrites, which are compounds of iron and sulphur, provide primordial atmosphere and also the essential properties for sequestering the energy sources for chemoautotrophic metabolism. These microorganisms can utilize the resources provided on the surface of pyrites for sustained metabolism. Hyperthermophiles discovered in these places are most closely related to the universal ancestor for all life. Some of the microorganisms that inhabit the iron–sulphur-rich environment of deep-sea hydrothermal vents are protobacteria, falling under domain Archea such as Aquificale members – *Aquifex pyrophilus*, *Thermocrinis rubber* and *Hydrogenobactor thermophilus*. Besides these, more recent sulphur bacteria such as Sulphococcales and Methanococcales have also been found in hydrothermal vents[7].

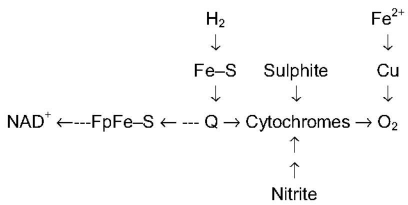
How do these thermophilic bacteria meet their requirement of water? These organisms were probably capable of obtaining their own water from the porous surroundings of sedimentary rocks. Hydrogen-oxidizing bacteria are capable of growing with hydrogen ($H_2$) as an electron donor and oxygen ($O_2$) as an electron acceptor. Thus, with the help of nickel-containing hydrogenases, the following reaction takes place:

$$O_2 + 2H_2 \rightarrow 2H_2O.$$

This is known as the 'Knall gas reaction', where one oxygen molecule plus two hydrogen molecules with the help of the bacterium produce two water molecules, as has been exhibited by some hydrothermal bacteria such as *Hydrogenobactor*.

We also know that several bacteria, including nitrogen-fixing bacteria have flavoproteins such as ferrodoxin, which can convert NADH into water. The enzyme nitrogenase responsible for nitrogen fixation, can reduce a variety of other reductants in addition to nitrogen. $N_2O$ can be reduced to water by hydrogenase. Carbon monoxide inhibits nitrogen fixation producing hydrogen. Similarly, hydrogen peroxide is produced as a result of oxygenic photosynthesis (Mehler's reaction), which can be oxidized by peroxidase into water. The reactive oxygen species (ROS) are otherwise deleterious and result in cell damage and inhibit growth of bacteria/cyanobacteria/green algae. Catalase can oxidize hydrogen peroxide to water and molecular oxygen. Some bacteria contain peroxidase, which can also use hydrogen peroxide to reduce NADH to NAD and water. Similalry, halobacteria, which grow under extreme saline environments (4M NaCl), extrude out protons.

Most members of the order Aquificales are autotrophs and obtain energy by oxidation of molecular hydrogen and reduced sulphur compounds[13]. *Deferribactor thermolithotrophum*, is a strictly anaerobic chemilithoautotroph that oxidizes hydrogen and reduces thiosulphate, elemental sulphur and sulphite. A similar anoxic, hydrogen–oxidizing autotroph with elemental sulphur as an electron acceptor was recently found in the isolates belonging to the Epsilon subdivision of the Proteobacteria from deep-sea hydrothermal vents[14]. Diverse anoxic, hydrogen-oxidizing chemolithoautotrophs are found among hyperthermophilic Archaea within the order thermoproteales utilizing nitrate, elemental sulphur, thiosulphate, ferric iron, arsenate, selenate and selenite as electron acceptors. Electron transport chains of several chemoautotrophs can be shown as under.




There is also a possibility of $H_2$-reducing hyperthermophilic bacteria, i.e. Aquificales being the main cause of change in the atmosphere from reducing to oxidizing.

These Aquificales are hyperthermophilic (>85°C), microaerophilic, chemilithotropic bacteria capable of oxidizing hydrogen and reducing sulphur compounds. Aquificales are able to use an aerobic respiratory chain[15]. Aquificales may have fixed carbon chemoautotrophically[16]. Most members of the order Aquificales are autotrophs and are capable of obtaining energy by oxidation of molecular hydrogen and reduced sulphur compounds and coupling oxidation of a wide variety of electron donors such as acetate, fatty acids, aromatic compounds, amino acids, etc. to the reduction of Fe(III), Mn or nitrate, arsenate, selante or selenite[13,17]. Possible mechanism involved in the above-mentioned process could be the following:

Iron III sulphate from pyrite ore

$$4FeS_2 + 14O_2 + 4H_2O \rightarrow 4H_2SO_4 + H_2O$$

$$2H_2SO_4 + 4FeSO_4 \rightarrow 2Fe_2(SO_4)_3 + 2H_2O$$

Copper ore (chalcocite)

$$2Cu_2S + O_2 + 2H_2SO_4 \rightarrow 2CuS + 2CuSO_4 + 2H_2O$$

Chalcopyrite

$$4CuFeS_2 + 17O_2 + 2H_2SO_4 \rightarrow 4CuSO_4 + 2Fe(SO_4)_3 + 2H_2O.$$

Proximal channels are dominated by filamentous sulphide and hydrogen-oxidizing species that comprise the group Aquificales. These Aquficales presently represent the deepest branch in the RNA tree. In shallow channels where flow rates are high, aquifer mats form bacterial 'streamers' that became encrusted, forming characteristic sinter fabrics that preserve original flow orientations. The fabrics are retained during the recrystallization of aragonite to calcite. Remarkably similar bacterial streamers have been described from ancient siliceous thermal spring sinters in the carboniferous Drummond Basin of Northeast Queensland, Australia[17,18]. This provides a clue to the formation of some water molecules in these vents by the sulphur/iron hyperthermophilic bacteria, the Aquificales. Such a study has not been undertaken so far. We, therefore, offer this idea of discovering and exploiting water-fixing/harvesting/synthesizing organisms from desert organisms or thermophilic bacteria. Promising probacterial groups from the Aquificales group having the ability to produce water, can be suitably engineered by genetic manipulation. These can be made to function in root nodulating-type symbiotic associations, thereby enabling the plants to synthesize water in the rhizosphere (root surroundings), so that the plant can thrive well in deserts or other places where there is no water. Implications of such organisms cannot be overemphasized, which may well be the forerunners for solving fast-depleting freshwater resources of the planet.

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## NEWS

# Geoscientific studies in and around Delhi: An update

During the last decade, India has witnessed many disastrous earthquakes – the 1993 Killari and 2001 Bhuj, which claimed thousands of lives and caused immense loss of property are significant among them. The Killari earthquake gave an impetus to the national efforts in terms of earthquake monitoring and disaster mitigation. Upgradation of seismic instrumentation with modern digital systems, setting up of a national data centre and other new studies initiated during the post-1993 period are yielding results today. While the detection capabilities have improved significantly, digital data streams have provided an opportunity to work on various seismological problems, including source characterization, estimation of ground motion due to future large earthquakes, refinement of crustal structure, attenuation relationship, etc. Both, the Killari and the Bhuj earthquakes taught us many lessons. Some of the important ones concern the site-specific nature of damage due to secondary effects such as liquefaction and ground failure. The liquefaction and ground failure were considered as the important