



Pachyderm and Petrichor: Searching for New Ways to Mitigate the Human-Elephant Conflict

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Abstract

Geosmin, a taste and odor (T & O) compound that has been hypothesized to occur in higher magnitudes in water bodies due to climate change, is a water quality parameter for human consumption, but an olfactory cue for elephants to migrate towards water holes. It is proposed here to culture bacteria capable of geosmin biodegradation for the development of a unitary, or a consortium of microbes, to lower the geosmin content in human settlement-proximal water holes, to discourage the encroachment of elephants to villages.

This novel idea aims to protect both, the elephant population and the human footprint in harm's way, furnishing a program to conserve elephants while ensuring that human lives are protected. The environmental and social impacts of this proposed nature-based solution will be centered on 1. Elephant conservation 2. Reduction of incidences of the human-elephant conflict, which together provide a natural solution to a dilemma that so far has lacked tangible, sustainable, and long-term, bio-centric remedies.

This editorial projects to protect both humans and elephants in a climate-change-impacted dry zone of Sri Lanka, where there are an estimated >5000-6000 elephants, which makes up 10% of the Asian elephant population in 2% of the range, the highest density of Asian elephants in any country. In an increasingly water-impovertised landscape, encroaching on human settlements for water and food flares up the human-elephant conflict that claims hundreds of lives across the human-animal divide, in any given year.

There is a quote by arguably the greatest artist that walked on this earth, Pablo Picasso, who coined this wonderful line *"God is really only another artist. He invented the giraffe, the elephant and the cat. He has no real style, He just goes on trying other things"*. We scientists too need to be like artists – "try other things" to save the opulence of biodiversity – those giraffes, pachyderms and big cats, threatened by habitat expansion and human encroachment, of which the elephant holds the pinnacle rung. This editorial is simply a wake-up call for the scientific community *to try other things*.

1.0 Elephants, olfaction and reward in a climate change-impacted world

The human-elephant conflict, a recurring theme in public forums, community gatherings, and newspapers, has no tangible and long-term solution to alleviating the fatalities that occur on both sides of the divide and has repercussions in an increasingly climate-change-impacted landscape. Human-elephant conflict impacts local communities, agroforestry lands and even dry zone

tourism, and requires evidence-based, multi-disciplinary interventions to solve this burning and catastrophic issue. This concept note proposes a tangible and long-term solution to the impending conflict and draws from the diversity of microbiology to conserve not just a keystone pachyderm but also to ensure that human communities are saved from future entanglements

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resulting in unnecessary deaths. The proposed program will assist in local and central governance-based reduction of the human-elephant conflict to safeguard vulnerable local communities in a climate change exacerbated backdrop, as well as to mobilize community engagement by education on the generated “knowhow” as a means for communal adaptation to a threat, to transfer surveillance and guardianship of local water reservoirs to grassroots organizations, while establishing and scaling up new user-friendly biocentric methods as long-term solutions, that may have impact, both locally and globally.

Elephants are known for their superior olfactory sensitivity and are receptive towards taste and odor molecules, one of them being geosmin which has a bearing on their receptivity to proximal and distant water resources [1]. Geosmin is an aromatic molecule (Figure 1) that is produced by cyanobacteria (photosynthetic bacteria) and actinobacteria (mycelial bacteria), which renders the water a characteristic smell and taste [2]. Even the smell of rain, which is termed “Petrichor” in the English language, is due to the presence of geosmin in rainwater.

While geosmin is produced by a subset of bacteria, another subset has been shown to be capable of degrading geosmin, and such bacteria include *Chryseobacterium* spp., *Sinorhizobium* spp. and *Stenotrophomonas* spp. that are able to proliferate in higher magnitudes in the presence of geosmin and transform geosmin into smaller reaction products [3].

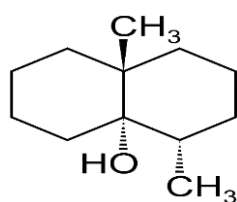


Figure 1: Chemical structure of Geosmin.

Climate change related phenomena are proposed to aggravate the levels of taste and odor compounds such as geosmin synthesized by selective cyanobacteria, due to stronger proliferation of the producing microorganisms at higher temperatures. The temperature is a key determinant for the growth of geosmin-producing cyanobacteria such as *Dolichospermum* spp. [4,5] leading to a higher presence of geosmin in water sources.

Eutrophication is a major impetus for the formation of cyanobacterial blooms, which are watershed events for prolific geosmin production. It should be

noted that eutrophication is more common in water bodies near human habitats and is less of an issue in natural forests and conservation sanctuaries. Climate change is also proposed as a barrier/hurdle to the survival of the Asian elephant [6].

Therefore, in a landscape of heightened presence of geosmin in water reservoirs due to climate change - especially ones that are near human settlements - there is concern that the human-elephant conflict may tip towards a higher incidence of mortalities/injuries across the human-animal divide. The elephant-human conflict took the lives of 145 people and 433 elephants in Sri Lanka in the year 2022, showcasing the timeliness and magnitude of this burning issue. Therefore, it is pivotal – and timely – that scientifically-proven, nature-based solutions are sought to tackle the elephant-human conflict to remedy its negative impacts at the grassroots level.

Professor Adrian Shrader’s group [Department of Zoology and Entomology, Mammal Research Institute, University of Pretoria, Pretoria, South Africa) has ongoing behavioral studies on elephant olfaction, especially the presence of geosmin, 2-methylisoborneol, and dimethyl sulphide in water that assists as olfactory compasses for elephants to locate water sources [1]. Professor Shrader’s group has shown that the olfaction of T&O compounds by elephants is a sensory stimulus in their gravitation towards water holes [1]. Concentrations as high as 3170 ng/L of geosmin (Table 1) have been recorded in South African natural water sources showcasing the magnitude of the issue [7] and the threat it poses to mankind. However, this olfaction-based geospatial positioning of elephants was shown only at relatively smaller scales [1]. Whether for long-distance olfacto-location of water sources by elephants, a similar relationship can be conceptualized and proven, is up to future research centered on this exciting topic. What is also significant is that elephants are known to track rainfall patterns, which again promotes geosmin – the donor of petrichor – as a key olfactory cue [1].

Table 1: High geosmin levels recorded from water sources of selective countries [7].

Country	Geosmin Level (ng/L)
Japan	400
Spain	86
Australia	4000
South Africa	3170
South Korea	1000

Olfaction in elephants is maneuvered by the reception (docking) of volatile ligands such as geosmin to receptors at the olfactory epithelium and discrimination of smell determined by the olfactory bulb [8]. More than ~1400 olfactory receptors are attributed to olfactory reception by Asian elephants, against ~400 in humans, which demonstrates the superior olfaction of elephants compared to mankind [9]. The olfactory bulb in African elephants is the largest in the animal world, with a volume of 59.9–62.4cm³ [9].

To protect and save this gentle giant that has a nose for water – and the humans accidentally in harm's way -, will entail the sanitization of water pools using biologically-proven geosmin degraders so that elephants will not encroach on human habitats sensing the aroma of geosmin-rich water. It is

projected that hundreds of lives of elephants and humans can be saved from this simple nature-based biochemical solution, especially in a landscape where climate change – with eutrophication - is proliferating cyanobacterial blooms and consequently, improving the levels of fragrant geosmin, i.e. petrichor, in water.

2.0 An Interdisciplinary Methodology and Research Action Plan

The methodology (Figure 2) of the proposed conservation plan can be divided into the following, specific, interconnected, and sequential multi-disciplinary goals. In all, microbiology, molecular biology, biochemistry, immunochemistry, chemistry, and GIS methods should be employed in this proof-of-concept study.

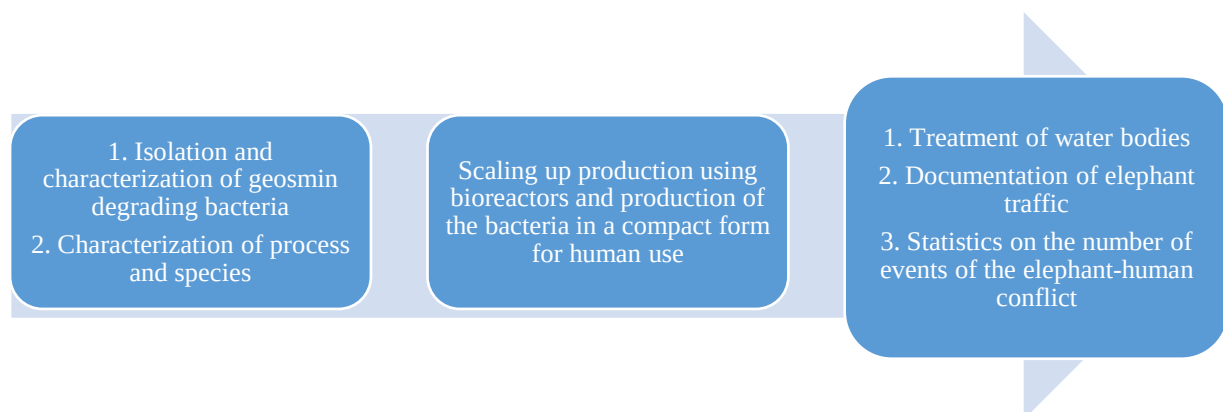
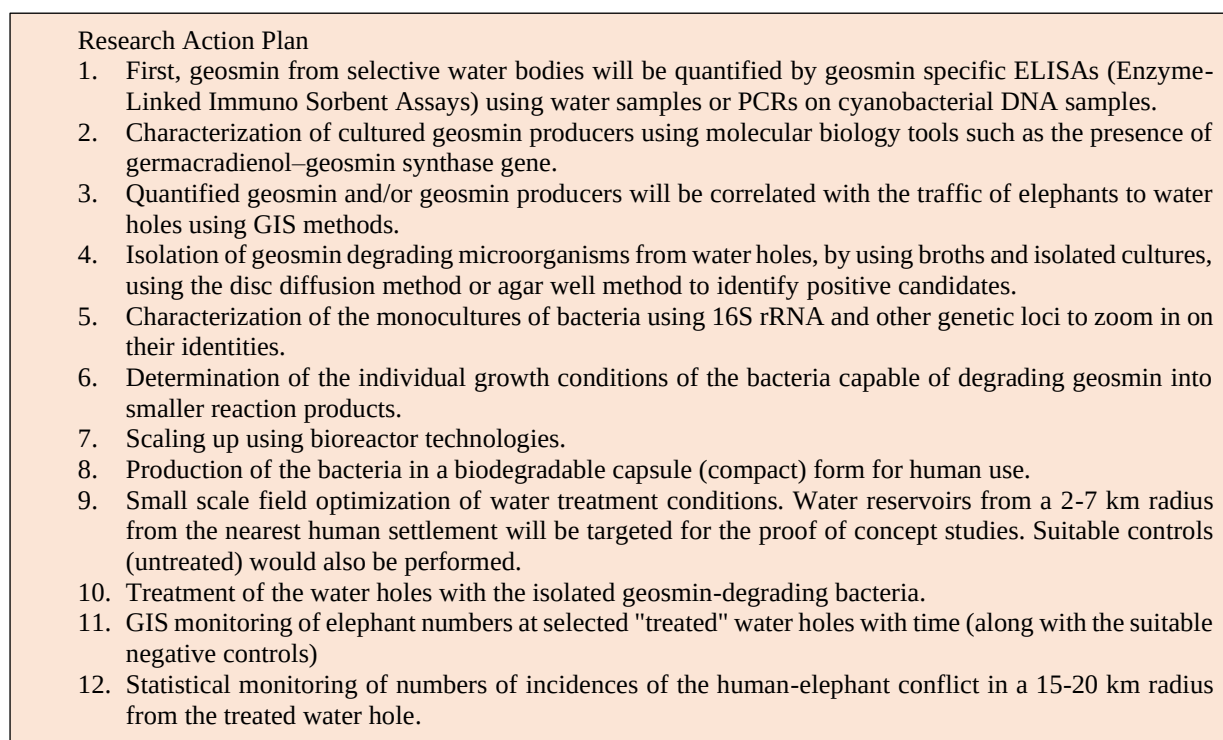


Figure 2: Simplification of the proposed methodology.

3.0 Broad Impact in a Real-world Scenario

The proposed study's most significant focus is to lower the geosmin content in water holes near human settlements by treating cultured bacteria that have the enzymatic arsenals to degrade geosmin to smaller, insignificant reaction products and thereby lower the geosmin fragrance-based traffic of elephants to nearby water holes. Elephants are known to consume water daily, although they are also known to take 2-3 day breaks in between attempts at quenching their thirst [1].

The projected basic sciences outcomes of the proposed study (Figure 3) are: 1. Basic sciences findings of geosmin as a chemoattractant of elephants to water holes. 2. Basic molecular sciences-based identification of geosmin bioproducers proliferated by climate change. 3. Demonstration of geosmin biodegradation by cultured microorganisms and bacterial consortia that can be employed to lower the geosmin content in water holes near human settlements 4. Identification of geosmin bio-degraders using microbiology, molecular biology, and biochemistry, which will form the foundation of bolstering the subject-level knowledge pool on the taxa of bacteria that have the molecular weaponry to degrade geosmin, which is useful for the sanitization of water reservoirs using bio-control methods. Being a nature-based solution (the bacteria capable of biodegradation are isolated from natural water bodies) there are fewer detrimental environmental impacts stemming from the intervention compared to synthetic chemical-based solutions that could have a strong pollution footprint.

The social and environmental outcomes (Figure 3) that are projected to contribute to saving the lives of humans and elephants and contributing to SDG 15 (Life on Land) are as follows: 1. Treatment of reservoirs near human habitats with geosmin degrading bacteria leading to changes (positive in outcome) in elephant migratory patterns in their search for water and food 2. Lower incidences of fatal and injurious events stemming from the elephant-human conflict can save hundreds of lives on both sides of the human-elephant divide. In addition, a bonus is that such bio-chemo-lytic treatment will make the potable water purer and more favorable for human consumption.

It is hoped to attract funding for the project outlined in this editorial, to perform a multidisciplinary study to furnish a solution to the human-elephant conflict, which is escalated by the density of elephants in Sri Lanka, proximity of elephants to human habitats especially in the dry zone of Sri Lanka, the scarcity in suitable food and water resources that leads to the

encroachment of elephants to villages, and the loss of forest land due to anthropogenic actions that enforce limitations on elephant habitats.

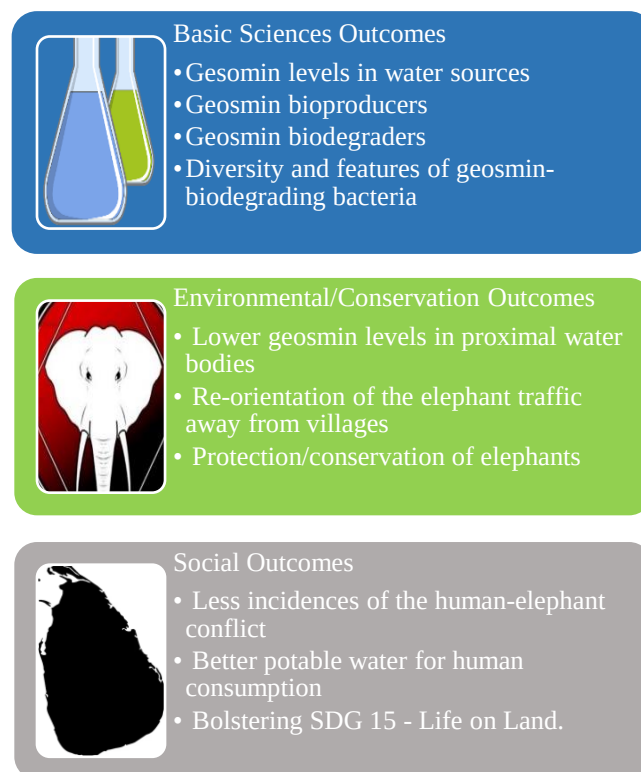


Figure 3: Three key categories of probable outcomes of the proposed program

It is projected that geosmin biodegradation along with bio-fencing (for example Citrus family plants such as oranges), spraying of nature-based elephant repellants (mono-terpenes) and other biocentric measures to diminish elephant encroachment of human habitats, can be suitably employed as a broad scale but integrated elephant management action plan to save the populations of the elephant, as well as humans in harm's way.

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