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'One Health' prerogative to illustrate environmental sink hypothesis of Accumulator Effectors

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ABSTRACT

The incorporation of the integrative character to highlight intercollaborative discipline of 'One Health' was done by World Health Organization to illustrate it as "an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes". The worldwide efforts to incorporate modern trends in detection, diagnosis and medication to the development of treatment strategies to counter threat of emerging parasitic diseases have necessitated to adoption of workable measures in the interacting space of environment, livestock and public health. To root out disease elements evolving sustainable efforts gained significant recognition so that concerted attempts could succeed to eliminate the agents of pathogeny and put severe restriction on their prevalence. The recent spurt of invasive parasitism into the freshwater riverine ecosystem of Ganges at Prayagraj by alien parasitic species of Anisakidae from Arabian Sea has triggered newer danger of zoonotic diseases into hitherto unaffected aquatic systems. The migratory avian visitors could well be a cause of transfer of unwarranted species from marine environment. Simultaneously, the human interventions to promote alien invaders due particularly to man-made alterations in the aquatic environment provided an opportunity to focus on serious one health event. The deposition of iron from the ambient environment on to the tissues of brain was detected to be linked with moderate drinking, and that resulted into cognitive decline. The recent reports of iron deposition in aquatic fishery resources through helminth parasites as 'environmental sink' have raised hopes to exploit beneficial uses of pathogens, through which parasites like, *Rotundocollarette capoori* (Yadav, Kapoor & Malhotra) drain in heavy metals, *viz.* Hg, Pb, Fe etc., as accumulator effectors, from even the tissues of the host fish to enhance its survivability.

Index Keywords: One Health, iron deposition, environmental sink, accumulator effector, *Rotundocollarette capoori*.

1. Introduction

The multiple scale approaches employed to meet the challenges of the emergence of mysterious infectious diseases equipped the ecologists and expert medicos better to ward off their illeffects in an effective manner. With the enhanced mobility as well as transfer of populations from one destination to the other in a rapidly transforming society adopting urbanization, the pathogens and other disease agents developed strategies to avoid epidemics and epizootics. The irresistive environmental changes and their interactive influence that comprehensively explained the concepts of nestedness, efficiency and resilience to crack the mystery of environmental implications among the networking space from the evolutionary standpoint. One Health1 conceptualized the very definitive attitude to make an over-encompassing resolute intent to decrypt the sudden explosive spread of pathogens that might set a narrative of vehement prevalence (Figure 1). The innovativity is marked as it amalgamated environmental, cleanliness, and population oriented transformation. Thus specifically the opportunities were wide open for scientists from various disciplines like, medicine, population ecology, anthropology and biology to work mainly because they were religiously sensitive to the climate change the effects of which were reflected in the refinement of urban development events that could facilitate a stringent check on the prevalence of infectious and related pathogens capable to cause non-communicable pathogenesis. The interactions wide across barriers of overlapping disciplines now necessitate to develop a scientific approach to de-escalate barriers for innovative researches across newer lines to succeed.

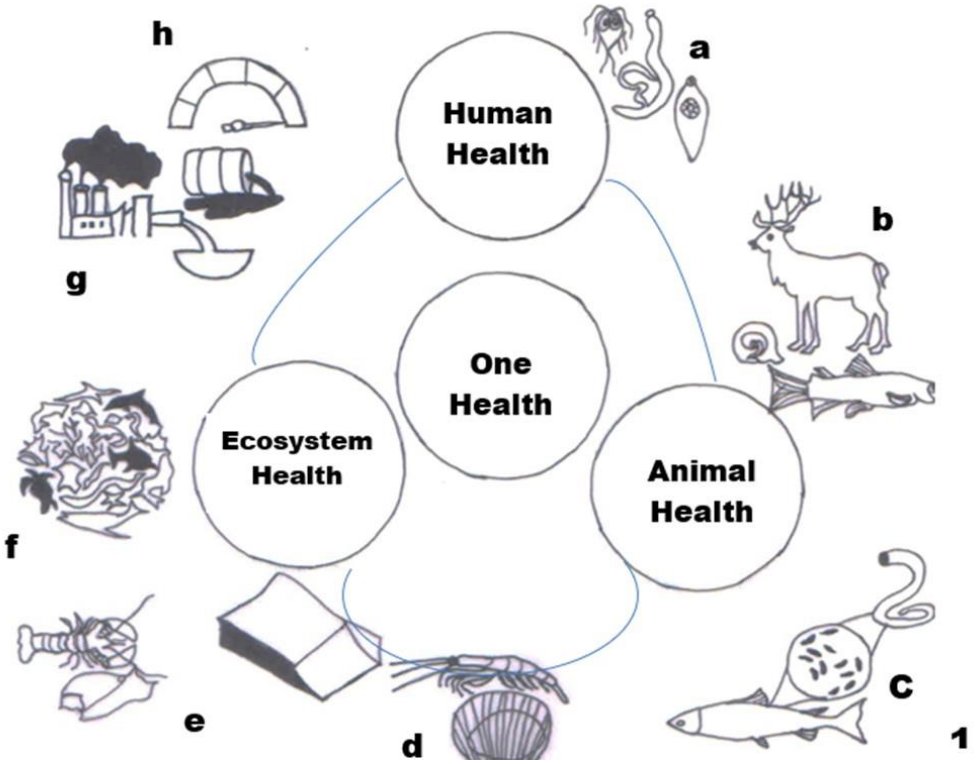

Figure.1: Elements (a-h) of one health concept.

2. Materials & methods

The sampling of marine helminthic specimens harboured by 50 *Johnius dussumieri*, 30 *Sillago sihama* and 15 *Rhincodon typus* as well as freshwater specimens of nematodes harboured in 48 *Bagarius bagarius* were recorded from varitable sites of infectivity within fish hosts were already the part of record[7,14]. The worms, after recovery from fish host, were washed in Hank's solution; fixed in 4% (w/v) Glutaraldehyde buffered with 0.1M sodium cacodylate (pH 7.4) containing 3% (w/v) sucrose for 4.5hr at 4°C. to conduct X-Ray Scanning Electron Microanalysis. t-test was conducted to work out level of significance between infected and non-infected tissues. The specimens were attached to the stubs for preparation of SEM photomicrographs for elaborate analysis of the body parts of the worms and tissues of the host fish. Each body organ of five worms of the same stage of development were subjected to analysis, and these were impinged twice to extract data on elements as well as metals. An Oxford Instruments detector was supplicated with the Field-Emission Scanning Electron Microscope (JEOL JSM-6510LB) to

conduct EDX (INCAx-sight Energy Dispersive X-Ray) microanalysis after[7].

2.1. ENERGY DISPERSIVE X-RAY MICROANALYSIS: The transformation of SEM employed to impart an electron beam into an X-ray composition comprised two stages. As soon as the atoms of the sample, introduced into SEM, are passed on some of the energy via electron beam, these are energized to "bounce" upwards to a "shell" with added energy, or are such electron is "knocked off" from the atom. Under the latter situation in the condition of such a transition a "gap" is left behind with positive charge. Hence the electrons from the higher energy shell are attracted towards this positive charg. Under the circumstances, the release of energy in the form of X-ray commenced to compensate the transtitional difference that left the referred "gap". Therefore, X-rays left a finger print of the type of element that constituted a sample, and this finger print was used to decifer the type of targeted element (metal)[7].

3. Results & Discussion

When the complications of the life style being on the rise, from an eco-health perspective[2], the operational functionality of several mechanisms as such with environment associated processes becomes unavoidable. The One Health proposition (Figure 1) addresses innumerable constituents as well as the adversely influencing agents of disease, in a complex situation, and at the same time under the influence of environmental interactions as well as the presence of organisms of pathogenic potential, such an eventuality triggered coordination with associated processes and coevolutionary events that represent sustained changes in the organismal transformation 3 over a period of time.

3.1 INTEGRATIVE APPROACH FOR ECOSYSTEM CONSTITUENTS

The judicious alternative methods and techniques are being suggestively applied to counter the effect of pathogens and other parasites as well as contaminants to optimize promotion of barriers for checks on transmission of pathogenic organisms. The conversion of farmlands into grasslands, like those of Jura Mountains, promoted the bulk entry of minor mammalian pests, as rodents and other small mammals that were associated with enhanced agricultural practices to shift ecological imbalance in favour of large-scale small mammalian territory. With sudden spurt in mammalian pests, the tapeworms like *Echinococcus multilocularis*, a worm of zoonotic potential, could form a part of disease outbreak of serious pathogenic potential in human beings. The public devastation by this tapeworm in the identically perceived fashion was earlier highlighted in China[4,5]. A serious application of systems approach for regulation of entry and prevalence of helminth parasite populations has been propagated, under the principles of "One Health" concept (Figure 1). This study presented the forcible extension of nematodes as against the adverse conditions generated due to biometals which may have induced contaminant effect vide 'one health' concept.

3.2. CHALLENGES TO "ONE HEALTH" CONCEPT:

3.2.1. Toxic Risk:

The impending disaster involving invader pathogenic helminths could imaginably be at varied levels. This would thus challenge the operation of "One Health" concept by way of detrimental influence of co-habitant parasitic pathogens, whose harmful effects would act as contaminant's influence that would interfere with physico-chemical interactions, endocrine and immune responses within the host fish's body. As a result, the biotic and abiotic interactions could easily impact the host-helminth interactions. Though at the same time the effect of pollutants and poisonous substances does not affect all the organisms in the same manner or at the same intensity. It is highlighted, therefore, that the nematode under investigation, *i.e. R. capoori*, was distinctly under influence leaving aside any damaging effect of other co-habitant parasitic organisms.

The potential of helminths for effective absorption of bile-associated lead that flowed in the vessels of intestine of the fish hosts resulted into fruitful operational resistance to avoid absorption of lead in the tissues of intestine of fish host. The differential absorption of toxic biometal, lead illustrated blockade of its entry into tissues of fish host to avoid detriment to host tissues and instead the worm's tissues acted as protector against toxic influence of biometal. This was experimentally illustrated[6] in chub, *Leuciscus cephalus* under infections by the acanthocephalan, *Pomphorhynchus laevis*. Thus the cycle of reabsorption of lead within the wall of intestine is interrupted through alterations in the biochemico-physiological

elements of hepatic-portal transport system. In the current investigation, more than double the content of lead detected from liver of infected fish (0.87 wt%) (Figure 2) than the liver of non-infected fish (0.39 wt%; P<0.005)[14] further received support from the earlier findings[7].

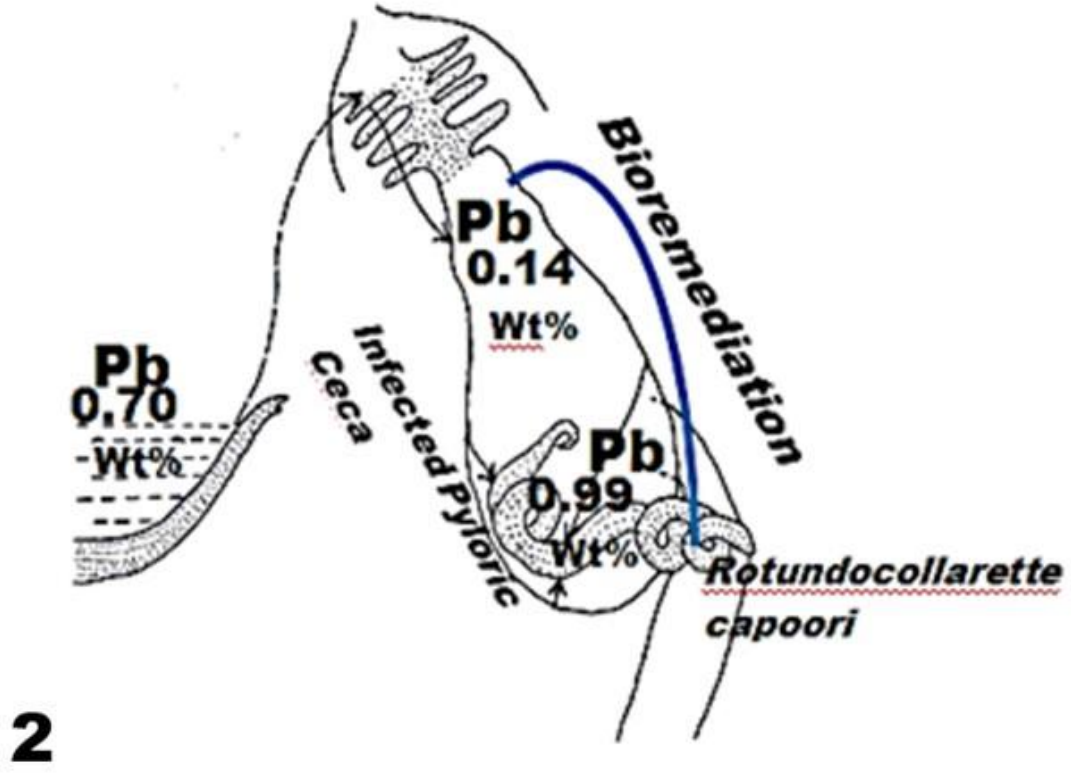

Figure 2: Aqua body-fish host-parasite transfer (conceptual) of biometals for bioremediation. (after Yadav *et al.*, 2026)

This has been asserted time and again[8] that the greater proportion of strength that the cuticularized exoskeleton derives, comes from the greater concentrations of sulphur, phosphate and calcium present in the bodily organization of the worm. The specialized cordons of acuariids were particularly assigned their inordinate strength because of the specific presence of S, Ca and P in the nematodes[8]. In recent years the functioning of naturally occurring sulphur bound ligands have been proposed to trigger protectivity[9] under natural environment. The sulphur reactivity that could interactively prevent the corroding influence of the detrimental effect by metal accumulation in the natural life systems.

The positive influence on the health of fish hosts by utilizing the heavy metal filtering capacity of iron absorbed by the parasites harboured in these hosts, was asserted[10]. Recently, the investigations[11] have also demonstrated iron affinity to the body tissues of alligators in the aquatic environment. The closest finding[12] to the present study has been on third stage larvae of *Contracaecum*, a member of Anisakidae that accumulated the metallic iron with properties to get transformed into two organic forms, like Fe reported from the camallanid worms, *Procamallanus* illustrated in a recent analysis[13].

3.2.2. Ecosystem integration and animal health interactions

The incessant outbreaks of pathogens of a variety of organisms, like tapeworms, nematodes, trematodes etc. are invariably linked to the prevalence and density variations of the infective stages of parasites and other infectious agents in the variety of hosts as well as vectors[10]. In recent years the transformation of helminth fauna to replace pre-existing species of roundworms in Arabian Sea at Goa have been explicitly established[14]. The commonly occurring *Paracamallanus* sp. encountered during long term investigations[15], in *Lutjanus malabaricus*, suddenly disappeared after 2006. These nemic populations were replaced by now appearing *Rotundocollarette capoori*[14]. But the crisis of environmental change under man-made conditions of climate change as well as natural upheavals resulted into a trigger to lead to the emerging infections by as many as five genera of roundworms, namely, *R. capoori*[14], *Paracamallanus* sp., *Pronakid goai.*, *Trypanorhyncha* and *Contracaecum* sp. as against single species of

Paracamallanus sp. The resulting community interactions by these nematodes that flourished simultaneously with disappearance of the fish host *L. malabaricus*, that was replaced by *Johnius* to harbour the freshly appearing community of[5] nematodes, named as above, amply demonstrated that occurrence of fresh nemic infections, provided ample opportunity to (i) analyse the dynamics of rapidly evolving pathogenic roundworms under natural habitats, and (ii) develop newer community interactions under altered aquatic habitat conditions, that made the earlier existing roundworm as well as its marine host extinct. Therefore, the ecosystem dynamics could be understood with a comprehensive knowledge of the surviving parasitic species. However, the intermixing of infectious helminth species between urbanized subjects and wild life could certainly be encountered inasmuch as that, zoonotic implications of tapeworms of Proteocephalidea, collected amongst cestodes, *Proteocephalus* sp. of fish, *Wallago attu* in wild forest streams of Garhwal Himalayas, near Kotdwara *tarai* area were recorded[16]. Human infections of *Proteocephalus* sp. in this region emphatically demonstrated environmental implications in the prevalence of cestode infections of zoonotic significance[9]. The in depth analysis of survey of helminth parasite data from avian, mammalian, amphibian, reptilian as well as fish hosts in Garhwal Himalayas over a decade between 1975 to 1986, alongside the environmental data on hydrobiological conditions, like, water temperature, hardness, alkalinity, heavy metals[6,7,9,14], chloride, dissolved oxygen summarily projected emerging helminth fauna of pathogenic significance that could well have zoonotic significance. The typical host switching was apparent with parallel transformation of morphometric parameters of the nematodes of raphidascaridoid roundworms that possessed strong cephalic features which were identical to mammalian[11] nematodes like, *Ancylostoma duodenale*. This would mean that coevolution mattered the most for gradually complicated highly evolved features to appear in worms, as parallel to their host fish. Accordingly the complications in cephalic apparatus of worms in mammalian hosts would match the strength with gradually gained strength from Fish --- Amphibians ---- Reptiles --- Birds ---Mammalian hosts. But in the present case not only that the cephalic features of nematodes of Raphidascaridoidea, that were encountered in fresh water catfishes, were so strong that they equally matched cephalic apparatus of anisakid worms from whales (mammalian hosts). This would project a picture of skipping gradual evolution of sturdy cephalic features from nematodes of fish to amphibians, reptilian, aves upto mammals, and instead their similarity in development from fish, directly to mammalian hosts was intriguing. As investigated by the author during past three decades in the area of Garhwal Himalayas, Gangetic plains and the West coast of India at Goa, the barcode analysis has comprehensively pointed towards emerging infections by invasive species of helminths from marine ecosystems to the freshwater ecosystems, particularly roundworms of Anisakidae (*Anisakis typica*, *Hysterothylacium* spp., *Contracecum* spp.), Raphidascaridoidea (*Indospinezia multispinatum*[17], *Rostellascaris spinicaudatum*[18]. As illustrated[19] the perfect alignment exhibiting monophylyly amongst nucleotide sequences of *R. spinicaudatum* parasitizing catfish (*Arius falcarius*) and shark (*Rhincodon typus*) in marine ecosystem with the four genes, mit coi, ITS1, ITS2 and 18S rDNA provided evidence of creditable nucleotide sequence alignment of marine *R. spinicaudatum* with that of freshwater species of *R. spinicaudatum* from *Bagarius bagarius* around Prayagraj, Fatehpur in Uttar Pradesh region. These investigations highlight the fact that transmittance dynamics of the constituents of infectious agent's life cycle, as well as the zoonoses-based emergence of infectious diseases had a greater role to play in transmission of infectious disease organisms[11]. Inordinately, the interplay of environmental events were responsible for diverse situations of transgression past barriers by helminthic organisms. The mechanisms of events like host switching could thus involve deviations due to interactions between biotic and abiotic factors. The Variety of hosts, transport of hosts[13,14,15,17] from the source of infection to its destination of spread and integrative approach to regulate sustained ecological processes have, of late, been identified as determiner attributes of diseases that emerged in a spurt periodically. Decimation of dwellings of inhabitant species and piecemeal construct of the destroyed habitations in concurrence with climatic alterations have a certain promoting influence onto the input of invader species. These frequently

colonise within the unnatural habitats[20,21,22], and combined with the naturally favoured habitat of *Lutjanus malabaricus* being coral habitats, the currently available habitat in the Arabian Sea being devoid of corals could have easily paved way for *L. malabaricus* to disappear or possibly this fish species was in tough competition with the cohabitant, *J. dussumieri* and thus having being deprived of comfortable food availability, the former has arrived at the verge of extinction presently.

3.2.3 Environmental sink

Long term investigations[15] concluded major influence of remarkable environmental factors on nematode dynamics. At the onset of Tsunami the roundworm *Paracamallanus trident*i[15] disappeared from *Lutjanus malabaricus* in Arabian Sea. With widening of range of infectivity, and resultantly widening of host specificity triggered intense infectivity in a larger variety of fish hosts in the same water body.

Concurrent host-switching was thus demonstrated with outbreak of *P. tridenti* in another cohabitant, *Johnius dussumieri* in which these nematode infections were uncommon earlier. This also lead to the emergence of *R. capoori*[14]. Such illustrations could well bring to notice the environmental influence to produce alterations in the pattern of infectivity of bioindicator parasites. But the resultant enhanced host range of helminth parasites could attribute to the term "euryparasitic". Thus the 'euryxenous' characteristic of such nematodes was ascertained.

Apparently, the exceptionally higher amount of metal Hg, *i.e.* 0.94 wt% (P<0.005) analysed from the tissue of the worm under study were actually drained out of the body organs of the fish at the site of infection, *i.e.* pyloric ceca[(14)]. Liver was the other significant organ which under status of infectivity accumulated 0.90 wt% Hg and 0.87 wt% Pb (P<0.005).

The potential of helminths for effective absorption of bile-associated lead that flowed in the vessels of intestine of the fish hosts resulted into fruitful operational resistance to avoid absorption of lead in the tissues of intestine of fish host[14]. This was also experimentally illustrated[(6)] in chub, *Leuciscus cephalus* under infections by the acanthocephalan, *Pomphorhynchus laevis.* More than double the content of lead detected from liver of infected fish (0.87 wt%) than the liver of non-infected fish (0.39 wt%; P<0.005) in the current investigation, further received support from the earlier findings[7,14].

Conclusively, the profound frequent occurrence of Pb (Infected Liver, 0.39 wt%; Non-Infected Liver, 0.87 wt%; P<0.005) and Hg (Infected Pyloric ceca-Proximal part, 0.94 wt%; Non-infected Pectoral fin, 68 wt%; Infected pectoral fin, 0.38 wt%; P<0.005; Un-infected Liver, 0.65 wt%; Infected Liver, 0.90 wt%; P<0.005) in body tissues of fish were noticed[14].

It is concluded that the nematode community bioremediated by accumulating heavy metals like Hg, Zn, Pb and Iron in their soft body tissues inside fish host. Thus fish survived of heavy metal pollution[21] as the roundworms, *R. capoori* functioned in the role of an environmental sink. Therefore, the iron and other heavy metals absorbed by the parasites by activation of heavy metal filtering capacity result into additive constituents of healthy nutrients being available to the body of fish hosts saved fish from illeffects of heavy metals.

Identical to the findings of the current study, third stage larvae of another anisakid, *Contracaecum*, accumulated the metallic iron in a fashion similar to the mechanism observed in *Procamallanus* used[10] in an earlier analysis.

4. Conclusions

The study, therefore, raised thoughts to another level for optimal involvement of the aspects of zoonoses utilizing animal health integration that interpolated host-environment interactions particularly in the aquatic ecosystems. The detection of biometals that occurred in contaminated aquatic zones were effectively absorbed by the helminths within fish hosts actually highlighted bioremediation of fish tissues from toxic effect of biometals. This is a unique finding that brought to the fore interdisciplinary role of various 'one health constiuents' to make beneficiary use of a zoonosis epidemics as well as the demonstration of a tool of mitigation of such public threats.

Conflict of Interest Statement:

Authors have no potential conflict of interest pertaining to this submission to the Journal of European Society of Medicine whether financial or non-financial, professional, or Proceedings from a Conference.

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Author Contributions

Conceptualization, S.K.M.& N.J., Collection & Investigation, N.J., A.Y., A.Y., Writing—Original Draft Preparation, Writing—Review & Editing, A.Y.; Visualization, S.K.M., A.Y. All authors read and approved the final version of the manuscript. Funding. This research is a part of independent research, and the findings of research investigations presented here were not part of any funded research project, nor any funding was received to conduct this research.

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