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Imperatives of Science of Sewage for Designing Efficient Wastewater Treatment System: Beyond Conventional approach to Sewage Management

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Abstract

Sewage is a climate linked science in that C and N containing compounds before their final sequestration stage are the most potential GHGs like CH4 and N2O. Therefore, their sequestration and or fixation is THE AIM of sewage treatment. Besides public health the sewage management is about climate health. All organic compounds in Sewage Treatment Plants (STPs), must be addressed at molecular level and not in terms of tonnage and billions of dollars invested on infrastructure and technology. Rivers are the anaerobic digesters of this planet. The process begins at zero order streams and urbanism has destroyed them long ago. Above all sustainable cities are a myth. Evaluation of conventional STPs reveal that it is a living cell membrane with a sandwich structure and gas diffusion through it goes beyond Boyle's law. Aeration and dilution for pumping convenience is a flawed path. Argument is that if atmospheric oxygen can be taken by a microbe in the aeration process, why do plant cells require Nitrifiers to take atmospheric nitrogen? Although CO2 concentration is 0.04 % against nitrogen (79%). Henry's law if applicable should not permit CO2 uptake by plants. Study reveals that Sewage degradation is an energy releasing path, any external input interferes with the process. Sewage treatment or transfer? Conventional STPs emphasize only gravitational pull. Also environmental quality is compromised as the aerosol from the treatment plant is carried in the atmosphere. STPs are throwing in the air Nitrous oxide and aerosol. Further this paper explains the Molecular nature of the sludge and conversion of Fecal acetate to Sludge acetate in ASP, achieving nothing in terms of wastewater treatment. Propagating the science of sewage and nature based solution for the wastewater treatment is the goal of this study.

Keywords: Sewage science; conventional STPs; Activated sludge; role of Microbes

Introduction

Rivers are vital ecosystem that support a wide range of flora and fauna and hence, protecting rivers and their associated habitats help to preserve biodiversity and maintain natural balance of ecosystem. Biodiversity indicators help us to understand how our natural resources are deteriorating with time. A recent WWF for Nature- Living Planet report indicates how worst is the situation of biodiversity across the globe. A comprehensive finding shows an average 69% decline in the relative abundance of monitored wildlife population around the world between 1970 to 2018 (Embargo Oct. 2020). Similarly, riverine ecosystem is under threat. Almost 75% rivers are either dead, dried, lost its riparian zone and flood plains which keeps it perennial. There are growing issues of serious water quality and scarcity, ground water depletion etc. Rivers are mainly polluted due to the untreated or partially treated drainage discharge. During Covid Pendamic lockdown if any sector worked unstoppable, was the sewage generation. This is only sector which will

keep running as dietary needs is necessary for survival of life. 330 CuKm/yr WW sewage generated globally of which 315 is domestic (Mateo-Sagasta & Raschid-Sally, 2015, 2017). Growing populations, more water use for flushing, larger pumping stations, bigger pipe via CLOACA MAXIMA- a five-thousand-year old legacy, without pathogen control, violated all basics of sewage science. Pumping of water with sewage to hundred kilometers for pumping convenience is factor for huge water content in the sewage treatment plant. In the process enzyme dilution reaches to an extent that degradation of sewage is not happening. Sewerage knowledge is important from the understanding that average per person throws out 200g of fecal mass. 70% is water and 30% is solid material of which 1/3rd is microbes. Microbes cell is a structural protein and its enzyme protein is 1%. So 1% of microbial enzyme concentration and adding so much water as per the calculation of per capita per person daily, slow down the process of digestion. In America it is presently 280 lt per capita per person and earlier it was 450 lt, other countries it is more or less the same. India had earlier 120 lt per capita per person and now it is 50 lt in rural and 70 lt in Urban areas. At 1% of enzyme of 20 gm of microbial body, how the enzyme efficiency will remain effective? Water or energy recovery is the aim of treatment plants today, whereas complete treatment of sewage and pathogens in the treatment plants are ignored. Moreover, flawed wastewater treatment plants are further polluting the rivers and water bodies. Hence regular cases of cyanobacteria and other species becoming virulent in the waterbodies in many parts of the world, restricting swimming, fishing and other recreational activities. Long ago NASA declared that ocean is the toilets in this planet. Repeated pandemics over these thousands of years is a proof of sewage illiteracy. And this is evident from water crisis on water surplus planet.

The net outcome of our approach towards waste water management:

1. Trillions of litres water pumped for pushing the poop in STP's, leading to water crisis.
2. Billions of dollars spent on infrastructure, not achieving much.
3. Millions of KW energy wasted in energy deficit society and.
4. We are still talking about the sustainable development and achieving SDGs.

Microbes do not understand infrastructure technology and Covid-19 proved it in that, most developed countries had higher death rate per million populations. Hardware upgradations i.e. civil engineering infrastructure and technology do need money. But then microbes do not care for hardware. Hardware is not a substitute for microbial role but microbial gene pool is important, however associated genes remain poorly studied (Kriaa et. al. 2019). Microbes can survive without us but we cannot survive without microbes, is rarely known to anybody. Many experts talk about enzyme chemistry but do not discuss the reaction part. No enzymes can work under the dilution for pumping convenience, as conveniently designed in the STP's. Hence, the present study was initiated by physical verification of the treatment plants in America, India and other countries with the perspectives of understanding the principles of each process in the Sewage Treatment Plant (STP). This study was conceived by the thought that if we do not understand microbes, all our system remain defunct as the calculations can go haywire. As Covid pandemic also proved this. The study is confined to empirical evidences collected of the STP's. The study begins with the assumption that there is insufficient microbial role for organic degradation in Activated Sludge Process (ASP) and no care for sewage science in the treatment process.

Aim of study

To evolve wastewater treatment with scientific clarity, holistic representation and inter- dependence with the river, for the sustainability and climate change resilience.

Methodology

Empirical study was conducted with the physical verification of the Treatment plants for its efficacy based on the principles of the sewage science. For this molecular nature of organic matter degradation in activated sludge and identifying the prokaryotes through metagenomics tool, is recommended to understand merits of the ASP. The study broadly covers India and global review of STPs on the molecular basis, mostly with the meta-analysis for scientific evidences. The below given points shall be discussed for clarity and implementation of right solution for sewage pollution of rivers in India and recommend site specific solution world over. A wrong

approach of wastewater treatment has compounded water and energy crisis, not to mention health of public and environment. Advanced technology can offer right solution if principles of science are well attended. Sewage management is basically a climate linked science, which is ignored for a long time. This study is important to relate as a) Public health is connected to pathogens b) Climate health is connected with prokaryotes not cultivable under ideal laboratory conditions. And they have to be studied with tools helpful for *in situ* studies. ASP is the bioreactor thus it requires a deeper study, along with the overall disparities or limitations in the process of conventional STP.

Hypothesis

The study is based on the hypothesis that in ASP, Fecal Acetate is converted to Sludge Acetate, so there is nothing achieved in a conventional Wastewater Treatment Plants.

Findings and conclusion

As we talk of treatment there comes chemistry, and with chemistry enzymes need to be discussed with molecular reactions. Dams gave us false sense of water abundance which lead to its abuse. Not realizing the fact that Dams provided a coronary block to the arteries (all rivers) of the Planet. This abuse lead to water crisis forcing us to recover water as an alternative source. Hence we need to treat the used water to reduce the withdrawal of water from the natural resources. Zero discharge policy is about not releasing water outside the premise. Therefore, first we need to understand that river is manifestation and not just a source of clean water. When the BOD (>30ppm) and COD norms were laid by the authorities it was imperative that flowing river water volume be eight times minimum of the release of the effluents. Since river flow is almost zero all over the places, the BOD allowable is 1ppm. World over the rivers only flow in the monsoon. The reason behind such a condition of a river flow is only the lack of understanding of the Sewage Science while creating the Wastewater Treatment Plants infrastructure and technology. This is why 'Not in my backyard' (NIMBY) syndrome appeared. Thus, partially treated water is discharged in the river which flushes in Oceans, ultimately oceans are contaminated. STPs discharge layouts are extended up to offshore regions in many places.

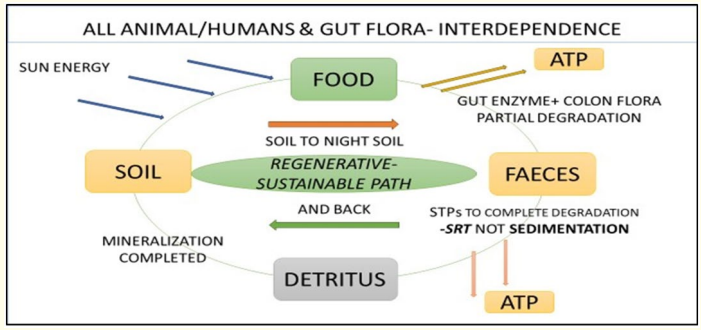

Figure 1: Schematic diagram shows that Molecule to mineralization process is regenerative.

Hence as shown in Fig. 1 a regenerative sustainable path is suggested, wherein a cyclic process of molecule to mineralization through the symphony of soil and sewage microbes, implying solids retention time (SRT) positively impact degradation of organic matter. Whereas in a conventional STP (SBR, MBR, MBBR) pristine water is used as liquid conveyer for pumping Sewage in grit sedimentation chamber to begin with the sewage degradation process in the primary tanks, followed by Activated Sludge Process (ASP), Return Sludge Process (RSP), dewatering by centrifugation, Anaerobic digester to kill pathogens in sludge, sludge transfer to landfills and finally Sodium hypochlorite treatment after tertiary treatment, only partially treats the wastewater.

Sewage Treatment Plant (STP) study is important from this accountability of water resource and Sewage concern is with general public, as everybody produces it. There is latent challenge and public health risk along with climate health. As with UV light bacteria gets killed but nitrous oxide still remains and aerosols it spreads. There are ample data available on the websites and other sources regarding the STP's monitoring. But with the understanding of the principles of sewage this study was initiated for sharing the sewage science rather than successful management of sewage. This study focuses on the 'black box' (Microbial Dark matter) of sewage science, Unit process and end product, as Sewage Science illiteracy is costing high in terms of Climate change impacts.

In this paper efforts are made to discuss sewage treatment integrating it with chemistry of microbes and molecular basis of reactions in a sequence. So we have made an attempt to discuss the microbial genome i.e. fecal genome and soil genome. CH_4, N_2O neutralization that is the end product that is what science defines. Science of Sewage relates to climate health, public health, phosphate content and breaking Cestode cycle. So sewage has only these four scientific aims. Other than that nutrient is supposed to go to the soil and beyond that recovering anything is exploitation and a mistake. And in sewage science, water for conveyance is not mentioned anywhere as it creates hurdle in the process. Water recovery in a STP itself is a flawed path because sewage does not need so much of water. In the treatment plant water is pumped but nothing is thought about the dilutions (MLSS) and release of Nitrous Oxide. And Nitrous oxide has spoiled the climate and that happens with solid waste disposal too. In the conventional method of STP, Climate science is not taken care off and hence the aim is destroyed. Earlier there was no water and nutrient recovery in the waste treatment process.

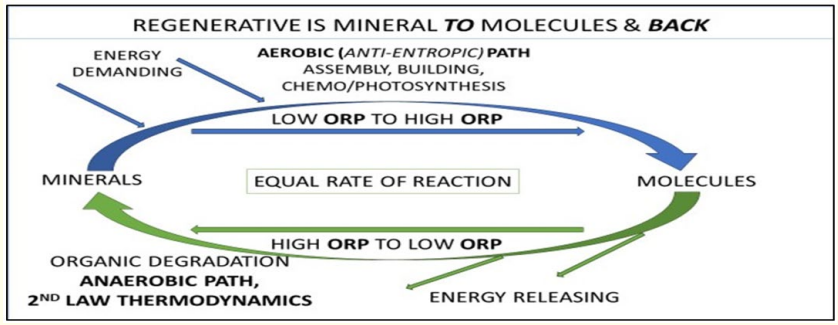

Figure 2: Schematic diagram showing anti-entropic pathway in aerobic condition with atmospheric air blower in conventional STP's.

Understanding the Human gut flora is important to know the regenerative sustainable path. Sewage degradation is an energy releasing path and any external input interferes with the process. Fig.2 diagram explains the anti-entropic path of organic matter degradation which is causing low oxidation reduction potentials to higher, against the 2nd Law of Thermodynamics as per the principles of sewage science. And thus equal rate of reaction is affected for the molecules to mineralization cyclic process as energy demand is higher with aeration facility in the STP's. Whereas in an anaerobic process energy is released in oxidation reduction reaction. Further, in the Activated Sludge Process (ASP) acetate degradation is not possible and when Acetate is fixed, simultaneously Sulphur breakdown takes place releasing foul smell. In most of the STPs authorities claim that the STP doesn't smell, but reason is that Sulphur breakdown process is not happening (Williams & Rickaby, 2012). They fail to realize that the process of organic degradation is remaining incomplete. ASP is reversal of digestive process. ASP converts C2 (major part of human feces) to Cn molecules hence it is opposite to digestion. Hence ASP needs to be understood deeply (Fig.3). Merit of Activated Sludge is an area to be explored more to mimic it with Human Colon and role of wetland in organic degradation. Sewage sludge analysis is Acetate plus Amyloglycogen. Conventional STP's convert Fecal acetate to ASP Acetate, so it is Acetate to acetate, what do we achieve with millions of KW power, MLDs of water and millions of expenditure on infrastructure technology? As sludge generated during the ASP and partially treated sewage water is reaching from the rivers to oceans. And NASA has reported that the oceans have become biggest toilets.

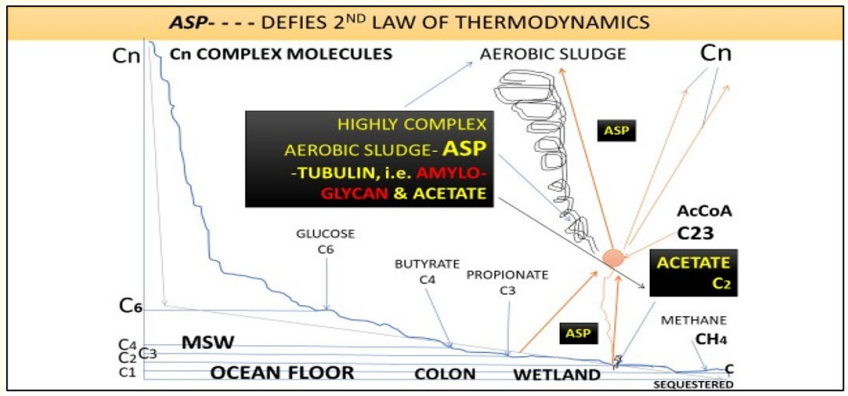

Figure 3: Schematic diagram showing how acetate degradation fail in Activated Sludge Process.

ASP is not converting the organic matter to Acetate (SCFA) and releasing it as it is in the river. Acetate is a food for Methanogens. Acetate cannot be broken down with chemical physical methods except treated at 150°C which will have other consequences. The only option is involving microbes through metagonomics study converting acetate to methanogen and FeS (iron Sulphur compound). Here H2S due to mal-odor is objectionable. H2S is soluble in water and converts to H2SO4 rendering the aquatic habitat acidic. All these molecules are heavier than water, therefore the ocean floor is acidic. Atlantic and Pacific is also become acidic. Its pH is increasing. So the sewage in bottom floor pH is 5.4 and top surface is 7.2. Why Pacific floor is acidic where surface is 7 plus. So many things unfold with different parameters in a chain of reactions. And composite picture we get.

Tertiary treatment is about Nitrogen and phosphate sequestration, so that it does not go out in natural waterbodies. Nitrogen formation is not there but its earlier form nitrous oxide (N2O) released in the STP's is ten times more than its emission in natural water bodies like Dams, paddy and estuaries. This sequestration is a very complex microbial process happening under anaerobic condition by aerobic microbes, where the oxygen source is NO3, NO2, NO, N2O and N2. If Nitrogen is sequestered that nitrous oxide will not form. 79% Nitrogen in air is for millennia and nitrogen is not harmful as it is an inert gas. Hence STP's are a source of N2O contributing Green House Gases.

After tertiary treatment for pathogen elimination chlorination is done in the treatment plant before effluent is discharged in the river. So N, S, Acetate, tertiary tank unit process needs to be discussed as chlorination is also not required at the final stage of discharge. Chlorine is produced otherwise also. Chlorination do not facilitate biological degradation instead kills both bad and useful bacteria. It is not natural process. Nature wants useful microbes to function. Science theory needs to be clear to design a treatment plant for right method of treatment process (Droste and Gehr, 2019). Hence it is imperative that the engineers of Sewage plant have to first understand the science of sewage.

As aeration of the STP bioreactor is done by the blowers as designed by the engineers (lacking understanding of biological sciences), they need to ponder that if bacteria can take atmospheric oxygen then why vegetation/forest does not take the 79% N from the air? and instead when same nitrogen converted to Nitrate in soil, fungi, why nitrifiers are required. Boyel's law and Henry's law of partial pressure do not explain CO2 intake by the plants. Living cell membrane is double layered structure and electrical charge is there in the living membrane. And O2 is a non-polar molecule and it does not have a charge and will not be attracted to the membrane. And Henry's law and Boyle's law is for artificial single membrane and not for double membrane. Otherwise if 79% N is there what is need of soil biota for the vegetation. Plants could have Straight taken gaseous nitrogen if 20% oxygen bacteria can take, as per the principle of STP aeration in the ASP bioreactor tanks. In Photosynthesis CO2 is 0.04 % and takes it but doesn't take 79% nitrogen directly. As per

partial pressure law of Henry's & Boyle's is declined. With the kind of concentration, first Vegetables must take N as per the 79% concentration. And if leaves could do all work then what was the need of the roots in the plant. So root zone ecosystem would have finished but can we imagine any healthy ecology without the root zone? Thus, Root zone indicates 79% atmospheric Nitrogen is useless. So how can be 20% atmospheric oxygen is useful in the treatment plant for which aeration is installed, engineers must explain. Biological preference for treatment with atmospheric gases is totally a different subject. And it's a living membrane not a physical membrane. Boyle's and Henry's laws (pressure exerted on a gas influences the solubility of gas in solution) never mentioned that their theory is for living membrane. For instance, if human skin could absorb Nitrogen why vitamins and other supplements were required. And N could have converted to nitrate and amino acids.

Jian et.al. 2021 reported in their extensive study and explained how Oxygen originated in ancient Cyanobacteria after the Great Oxygenation Event (GOE) and Phosphorothioate (PT) activates polymerization by altering the binding affinity of repressor and the transcription level of its encoding gene. In the same study Sulfur-based metabolism has been suggested to be very ancient because sulfur-metabolizing cells have been preserved in 3.4-billion-year-old microfossils. As earliest oxygen-producing life forms, Cyanobacteria are thought to be responsible for steady increase in oxygen concentration on Earth by oxygenic photosynthesis. Nostoc is subsection of cyanobacteria has ability to form heterocyst for nitrogen fixation. Phosphorothioate polymerizing agent SPO3-3 this is the most important molecule without C, H, N. In this context it is important to know about the anoxic world (see fig. below).

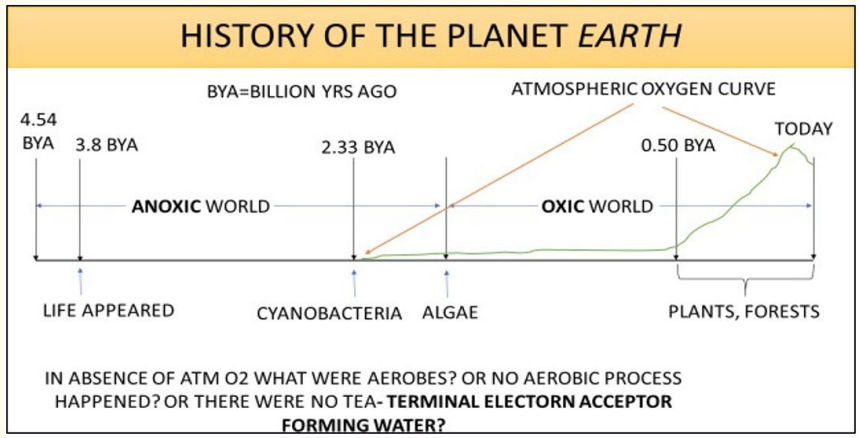

Figure 4: Schematic digram to explain the anoxic and oxic world era and role of cyanobacteria.

Oxygen is essential for life of earth but this was not always the case. Before 2.4 billion years ago earth was a virtually oxygen-free environment and appearance of cyanobacteria or blue- green algae changed all that. They pumped more oxygen but the levels remained low for next 2 billion years. Derouin (2019) reported that Nitrogenase an enzyme produced by cyanobacteria probably sustained it low. Non-oxygenic photosynthesis, cyanobacteria cracked the photosynthesis code and introduced oxygen to the atmosphere. They took Electrons from water H2O for photosynthesis, so by-product of photosynthesis is oxygen, and this new gas accumulated the atmosphere. This event is called Great Oxidation event which marked end of Archean. Oxygen (reactive species) is dangerous to life. As Oxygen is dangerous chemical for cells because it attacks all C/H compounds. C/H + O2 give CO2 + H2O and is thus a pollutant. Fe2+ and H2S reacted faster with oxygen which protected the carbon (Williams & Rickaby, 2012). Early life originated 3.8 billion yrs ago. Cyanobacteria gave rise to oxygen nearly 3 bn YA. However, from -3.0 bn y to -0.75 bn YA, C became CO2, N as NO3-, H as H2O and S as SO4. It was the origin of Nitrogen Synthatase that allowed free O2 released as atmospheric oxygen. And that O2 is plant excreted gas as we exhale CO2, and todays free O2 level achieved only 500 MYA. This explains the standard oxidation/reduction potentials.

For the aeration (Atmospheric oxygen) practices in the Sewage units it is important to understand that the Oxygen for degradation came from labelled H2O and not from O2. Here O from H2O is a bound molecular oxygen (Sawyer, 2003). That of O2 is unbound molecular oxygen. If aeration is for mixing purely a mechanical action (MLSS), why link it with aerobic bacteria that has a physiological connect? Anaerobic, aerobic facultative are genomic expression of a microbes having a preference for TEA Terminal Electron Acceptor (Facultative anaerobes adjust metabolism (active/negative En values) in the presence of oxygen bearing inorganic compounds such as nitrates and Sulphates). Bringing air using blower for mixing favoring AEROBIC bacteria and Archea is a crude approach with no recognition of the metabolic paths involved. Composition and classification of microorganisms and their role biological process for wastewater treatment consist of mixed communities with a wide variety of microorganisms including bacteria protozoa, fungi rotifers and possibly algae. 'Prokaryotes play a major role in biological wastewater treatment (Eddy and Tchobanoglous et.al. 2017).

In Aeration systems oxygen concentration is an energy consuming process. Oxygen is very insoluble in water and requires special considerations to ensure high absorption efficiency. Oxygen dissolution equipment designed for air only optimizes energy consumption because oxygen is free and efficient oxygen absorption is not relevant. The cost of commercial oxygen rules out the requirement of more common aeration equipment alternatives. Oxygen has such low solubility in water because it is a non-polar molecule and water is polar. The oxygen atoms share the electron in the double bond equally and thus have no partial charges.

Be if a Colon, a septic tank, an Anaerobic Digester (AD) in a STP, or in landfills, mangroves, estuaries, where organic degradation takes place, all of them follow principles of anaerobic digestion- 2nd Law of thermodynamics, heat releasing-exogenous, even when exposed to atmospheric air. For temperature of AD in STPs to be effective, it should be maintained at 36-37°C, which mimics that of human body.

Along with the corrective measures for STPs reorientation as suggested above, phosphate content in the water body needs attention as this is another factor which is important to understand for treatment. Every flood brings lot of phosphorous to the Dams and it gets accumulated over the years. Anything more than 1ppm phosphorous is objectionable as per EPA and it must discontinue. All Dam waters contain more than 1ppm and that is violation of EPA. That couples us to discontinue the Dams or change EPA specifications for phosphorous. So more than 1ppm phosphorus is affecting the vegetation and flora downstream. Hydraulic Engineers and Civil Engineers have to recognize this relationship. Dam water flow from hills and with it brings lot of phosphorous and settles down. High levels of phosphorous cause increased growth of algae blooms and decreases levels of DO, this process is called eutrophication. Recent reports have established that Algal toxins harm human and animal health. Also in the treatment tanks of STPs such blooms are observed. Also, STP's are chimneys throwing aerosols and GHG's in atmosphere, same as industrial companies pollute through their chimneys. Nature is indicating that Nitrous oxide and water vapour content is increasing.

With reference to the Tertiary Tanks, NO3-->NO2-->NO-->N2O to N2 is accomplished by the various communities of denitrifiers all working in a harmony. Denitrifiers are slow dividing members demanding longer Solid Retention Time (SRT), conventional STPs do not permit. It is important to note that from NO3 till N2 each conversion is influenced by a different group of denitrifiers and no single community can bring about all conversions. Not only that no single community can influence all conversions. And that is "microbial synergy" no STPs with their engineering hardware can match. Davis, (2010) reported that denitrification is independent of DO concentration. Denitrifiers are aerobic using oxygen bound to NO3, SO4 anaerobic, Anoxic environment.

For the C:N:P ratios wastewater values are defined on this proportion, any discharge not matching this is NOT acceptable.

All classical books on sewage science have defined these goals;

Protecting public and climate health, meaning pathogen elimination. Rotavirus, Cryptosporidium, and Cestode ova are resistant to chlorination. Of course, the latter eliminates even useful microbes.

Protecting natural water bodies by controlling phosphates and nitrates. That is exactly where constructed wetlands (CW) have a role no hardware can match. In CW aquatic vegetation have a structure called "rhizome" which grows 10 times faster than the above ground plant tissues having S:N ratio of 1:36 or 37. This is the only way to diverting N2O. The rhizome formation far out classes denitrifiers know the rate of nitrogen fixation. So, Sulphur and N are contained. Moreover, rhizome is a bound phosphate. To sum it up, rhizome with all its complex tissues is a huge store of N,S,P and being green it fixes CO2. This is molecular symphony played by a living cellular system.

ASP with all heavy molecules have S:N ratio of 1:16. Low Nitrogen to Sulphur means more N2O releases in environment. This is a molecular proof for why more N2O in air at STP sites. In constructed wetlands, Sulphur binds more nitrogen, that is N (N2O) fixation in fast growing rhizome. Moreover, rhizome being green with chlorophyll it fixes CO2 and releases O2. Thirdly rhizome is a bound phosphate. Here Sulphur plays an important role in fixation of all C, N, P. ASP is engaging half the nitrogen compared to rhizome. ASP organisms are amoeba, paramedic, worms, daphnia, tardigrades etc. All are animals so there is no carbon fixation. Thirdly, lower eukaryotes skin of ASP members engages less phosphates than cambium and bark of plant skin. Plant tissues like bark, lignin, cambium, are very complex nitrogen molecules. We all know that carboniferous forests fossilized 150 tp 250 million years ago have remained buried and are source of CH4 and petroleum products today. In the process their M2O and SO2 release are huge contributors of GHGs today. All fossil fuels are from buried forests, plant tissues. That means they held all that CO2, CH4, N2O, SO2 for so long. That is the chemistry of organic degradation. All end products are analyzed and identified. Acetate is a radical just one H less than in acetic acid. Each H determines the acidic nature. Carbon polymers from any source, forests, dead animals, be it a heap of cloth or paper, cardboard, oil, petroleum products, grease, all organic matter will end up as acetate. Acetate is the raw material for CH4. Similarly, all polymers with NH2 group will end up as N2O before nitrogen sequestration. C,H,O, of proteins etc. will lead to acetate. Here Facultative bacteria plays the pivotal role for acetate degradation, which is not possible in conventional STP's.

If organic or industrial waste breakdown process has to be discussed, in situ metagenomics tools (to identify the organisms) is the way out. DNA sequencing of the main group of organism is must, as there are different communities of the microbes. Return of activated sludge (RAS) is like making genepool. World over the ASP is followed by Australia only by natural wetland method. And nowhere desirable results are achieved and therefore it is flawed path. So we need to study to know how much the ASP is a reliable path. For this molecular nature of activated sludge and identifying the prokaryotes through metagenomics tool, need to be evaluated. As it is generated in huge quantity and transferred to the landfills at long distance places. As precarbon molecules is important to understand. CO2 is not organic. Glucose is not CO2.

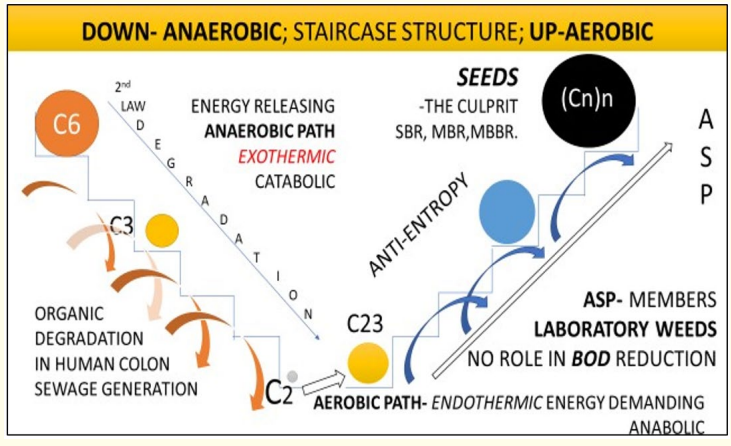

Figure 5: In Activated Sludge Process in STP's microbes have no role in BOD reduction.

Sequencing Batch Reactor (SBR) also inherits the same flawed legacy of SEED organisms which are protozoa, Rotifers, worms, daphnia, Tardigrades, all DO breathers (Seviour and Nielsen, 2010). These organisms eat smaller (lower carbon) molecules. When dead the same organisms contribute higher complex molecules that make sludge difficult to handle. And sludge is a headache for sewage engineers for over a century ever since ASP SEEDS were considered important. The drawback starts with SEED organisms, also called inoculum. That disqualifies Return of Activated Sludge. ASP, SBR, MBR, MBBR types of STPs, all have common defect in SEED organisms. BOD or COD parameter is flawed way to declare any STP or sewage treatment appropriate, as there is no role of ASP members (mostly eukaryotes) in this process.

Medical fraternity has used more scientific term calling fecal matter as "night soil" conveying that all nutrients from the soil to food must go back to the soil. Sewage Engineers chose ease and convenience over the right using pristine water to push the poop. Rivers are the anaerobic digesters of this planet and the process begins at zero order streams. Hence it is important to revive them as urbanisation has destroyed them and sustainable cities is a myth. For the waterbodies rejuvenation we need to determine to build STP's with the deep understanding of sewage degradation science.

Recommendations

To study the important factors to care for public and climate health:

1. Zero order streams up to the confluence of river in the ocean, as it mimics human body and river, as rivers are given a status of living entity.

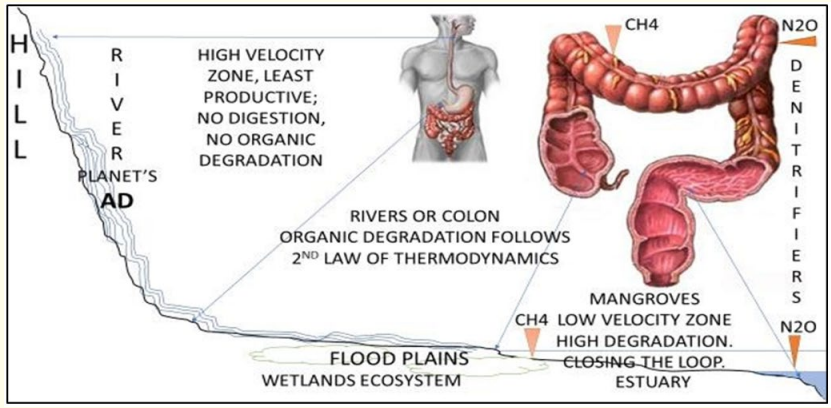

Figure 6: Schematic diagram showing human body mimics a river.

2. Anoxic era independent of atmospheric oxygen and ecology of earlier world.
3. Pathogens for public health.
4. Climate health - CO2, Methane, Nitrous oxide and water vapor. 5- Phosphorous pollution.
5. Discontinuing the cestode cycle, as cestode ova will survive for millennia-270 million year means before Pangea (one land one ocean stage of earth) as continents later formed. Worms ova preserved as per the carbon dating done. These ova are resistant to chlorination and thus ova and worms are transferred to the landfills with the sludge.
6. Acetate degradation in ASP and simultaneously Sulphur breakdown as it produces aerosol.
7. Molecular nature of sludge in ASP.
8. Septic Tanks/AD, role of prebiotics (Ca, Iron Chlorine etc.), wetlands and importance of SRT.

9. C:N ratio for methane generation. 10-15 Carbon added to do this. How worth it is to waste this energy?

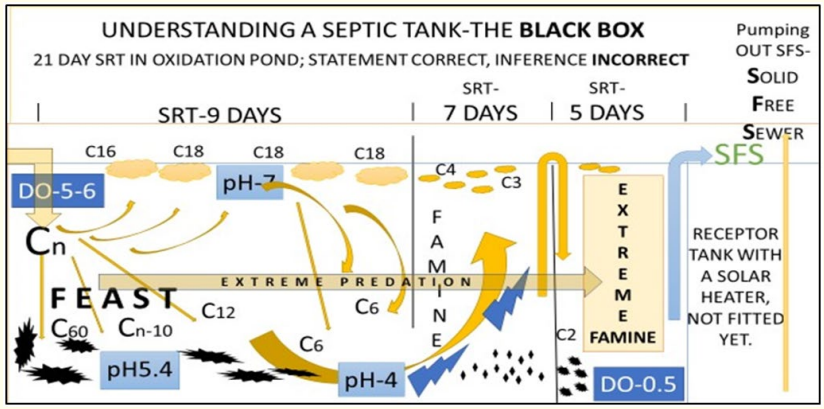

Figure 7: Solid Retention Time required for sewage degradation process.

10. Redox potential for energy requirements
11. Dewatering process
12. Chlorination of tertiary water

To study the Principles of Sewage in context to the STP's design for corrective action:

1. Phosphates and Nitrate degradation requires a long time. Conventional STPs do not allow this simply because of high water volume, receiving tanks are not designed to accommodate. So, when the next batch comes, the existing one has to vacate. This is total disregard to the microbes involved in the process. As a result, the complete reactions continue in the landfills. Need to ponder on the fact, how O2 is outcompeted by H2S, SO2 & NH3 (all during organic degradation) due to their high solubility over O2.
2. Organic degradation in a conventional ASP path is about building higher polymers more complex in nature with high ORP (Oxidation Redox Potential). Human gut refuse is already degraded stuff with low ORP. Food is Cn. Feaces is C4, C3, C2. ASP organism are n raised to Cn; (Cn) raises to n. Digestion is breakdown path following the 2nd Law of Thermodynamics. ASP is a building path (anti-entropic). Therefore, the resulting sludge is difficult to break and it takes months, years to degrade in landfills
3. After treatment of wastewater; discharge properties i.e. How Clean is clean? C:N:P, 106:17:1 as per molar proportion, 46:7:1 as per molar mass basis. In all Dam water discharge phosphate content is more than 1ppm which is not good for irrigation.
4. Early-earth environment was Anoxic. What were the aerobes then? Or aerobic bacteria did not exist in early world? Or is it that atmospheric oxygen existed in ever since the birth of the planet?
5. Advanced oxidation through –OH (a bound molecular oxygen) and not atmospheric O2 (an unbound molecular oxygen).
6. Resulting sludge a big problem. Metagenomic analysis of ASP as amoeba, ciliophores, rotifers, tradigrades, etc. found and whereas none of them is found in human colon
7. Addressing the mal-odorous gases – about Sulphur treatment, except for pushing it away to a few hundred kms of sewerage length by laying pipelines
8. Dilution of poop in contradiction to recovery of water, with the role of sewage management
9. How we justify STPs that are 10 times emitting more N2O than those in paddy fields, Dams and estuaries. As in India we propagate how N2O is fixed and P and bound phosphate in rhizome formed in wetlands
10. Mixed Liquor Suspended Solids (MLSS) for Food-to-Microorganism ratio determination, Acetate forming microbes, Acidification,

11. SO2 and water pressure produce H2SO4 that is highly corrosive and all sewage structures must be replaced every 30 years, how is it done/ or will be done
12. Ozonation- O of O3 kills microbes (pathogens and other useful microbes) and O2 escapes in atmosphere without participation. In aeration the same O2 blown in by blowers or compressors increase DO as if water (a liquid) can identify O2 coming from O3 not allowed and that of atmosphere is allowed to increase DO. As atmospheric oxygen is not soluble in water.

To explore alternatives like decentralized segregation of wastewater prior to pumping in the STP's. Like separation of urine, grey water, fecal matter (by commode design), etc. at source.

Replicate the models of Wetlands created in Kolkata, India and Australia and few others have adopted.

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