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PRESENT

WASTELESS CIVILIZATION

Developing the concept of zero-discharge economy.

US PATENT Pending

WORKING TOGETHER
FOR WASTELESS TOMORROW

The ideal economy should be self-sustaining and resilient. An ability to adjust to changes in population, economic growth, natural hazards and variability in production and demand requires a level of sophistication at all stages of production, processing, and waste management.

A major limitation is likely to be the use and re-use of water and the optimization of all systems using the best available technology to approach the concept of zero waste. The MIP/MAP technology is an example of a disruptive technology that can not only assist with the processing of liquid wastes, but it can also assist with treatment of many mining and industrial wastes, some air pollutants, and solid biological wastes.

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The technology is based on a major scientific and technological breakthrough - Micro-pulse Micro-arc processing (MIP/MAP) in rotating electromagnetic fields. This technology enables the conversion of organic and inorganic sludges, mine tailing accumulations, sewage from all sources, industrial waste including many types of hazardous waste (organic and non-organic) and even construction waste, into raw materials for reuse with minimal processing.
For example, organic waste is quickly converted into fertilizer as high-quality organic fertilizer, removing chemical impurities elements to low levels. Similarly, non-organic waste into metal oxides or stable chemical components, materials for use as high quality construction materials (silica, alumina, mixed oxides etc.). The separation method using settling or floatation provides a low-cost high purity product.

MIP/MAP can potentially enable us to reprocess most types of waste into major sources of key materials, while minimizing waste from many existing industries thereby preventing new accumulations.
The need to conserve and recycle our water reserves is critical to the industrial and socioeconomic economies. With cost effective and technological efficacy for capture and recycling of pollutants this will prevent them from reaching streams, rivers, and lakes. It also enables water re-use.

The incorporation of MIP/MAP type technologies into existing systems will allow us to approach the ideal of zero discharge and total re-use.

Economic and Financial Benefits

This technology has the following financial advantages when compared with the BAT for comparable processes:

1. The initial capital costs are reduced by up to 80% and are typically 50% lower;
2. The footprint is similarly reduced by an equivalent amount with reductions in building sizes, land acquisitions and buffer zones;
3. Land requirement for associated buildings and external infrastructure can also be reduced by up to 80% as holding ponds and secondary processing equipment is removed;
4. Associated process equipment such as motors, compressors, pumps is reduced by up to 60%;

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5. Personnel based operation and maintenance (O&M) costs are reduced due to the simplified processes, the self-contained equipment and less hazardous processes;
6. Electric power costs will be reduced by up to 70%;
7. No extra biosolids are produced in this process. Organic and inorganic based solids are separated out for reuse and reprocessing. This can be an additional income stream depending on the waste composition.

The actual benefits will depend on the site and treatment characteristics. The figures quoted here are for typical comparable plants that are biological or biological/chemical treatment systems for advanced secondary or tertiary treatment.

Environmental Benefits

The systems are fully enclosed treatment processes that require no major oxygen inputs as with biological processes and no biological inputs. They are not a reservoir for antibiotic resistance, and after the initial(conventional) solids screening there is no exposure to the atmosphere and no production of odors or development of nuisance organisms such as midges. The biological fraction of solids residues is suitable for direct use as fertilizers and are stable.

The technology provides the first opportunity for zero discharge processing of domestic and industrial wastes with on-site or local re-use. Alternatively discharge of the water into the environment permits the release of low nutrient water without the risk of eutrophic waterbodies or the need for significant flushing or dilution flows.

MIP/MAP - a novel technology for processing air, water, and solid waste materials.

1 Introduction

Most 'new' technologies that are presented for dealing with environmental contaminants are either specific to the target, incremental improvements to existing technology or need supplementary technology to deal with by-products or concentrates. The aim of zero waste with zero discharges accompanied by lowered energy, smaller footprint and flexible – fast start up and shut down to and from full operation, has been met in very few instances and then only for a limited number of applications. Accordingly, industry - and regulators, is stuck with traditional technologies that have well-known limitations. There have been incremental improvements over time or novel treatment technologies have been added to the process trains but the goal of zero discharges is missing. There are also very few (if any) technologies that can be used for the treatment of gases, liquids and solids using the same physicochemical or biological principles.

In chemical treatment processes, impurities are removed as particles from the water as precipitates or colloids. These are accumulated in settling tanks prior to discharge in permitted areas or for delivery to shore based waste units. The shortcomings of existing systems using physical and chemical principles of purification include high construction and operating costs; the need for cleaning of units; complexity of the control and monitoring systems, large bulk and mass, and the need for specialized ventilation and additional safety measures for confined spaces.

These are often combined with membrane or other types of filtration systems to remove residual solids or microorganisms.

A further disadvantage of chemical treatment systems is that the treatment products prepared by these methods can contain residues of chemically active substances that are harmful to the aquatic and marine biosphere so further treatments are required.

Biological treatment of wastewater uses bacteria that process impurities into a substance that can be removed overboard. Biological treatment systems require creation and maintenance of optimal conditions for the existence and multiplication of bacteria, with considerable time required to put the plant into operation after prolonged interruptions to operation. While marine based biological systems with brackish or saltwater are now relatively common, they are sensitive to changes in feed water composition. Biochemical treatment units need to be continuously fed to avoid incomplete treatment or prolonged start up times. When the delivery of wastewater to the unit is reduced or stopped, the sludge(biomass) activity reduces with corresponding reductions in treatment efficacy sometimes for extended periods.

Widely used technologies and equipment for disposal of wastewater use multistage cleaning methods: reagent treatment, coagulation, aeration, sedimentation, filtration, neutralization of slimes, clarification and more. An important factor that degrades the technical and economic efficiency is the low process intensity in the operating zones due to relatively low concentrations of the active components. Processes are correspondingly slow so that the size of the equipment is large, with low material and energy efficiency.

The MIP/MAP technology uses a completely different method of generation of multiple forces and reactive agents to treat materials. Details of the technology are in Appendix A, but the principles are outlined here.

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The technology provides for the passage of material – gas, solid or liquid, through a tubular reactor in which an inductor generates a rotating electromagnetic field. Ferromagnetic elements(indenters) that are needle shaped are placed in the working cylindrical zone of the inductor/reactor. The working elements oscillate, reaching several thousand periods per second. For a short time, electric circuits are formed in which strong currents arise to form temporary circuits. When these circuits break, many micro-arcs arise. When moving, the working bodies continuously emit powerful local micro-impulses and micro-arcs – MIP/MAP. This facilitates intensive mixing of the media being treated and the dispersal of materials. The high-powered local shock impulse action from the chain breaks acts on the material being treated.

Several effects are generated that combine with the local thermal and mechanical phenomena that occur when the working bodies interact with a substance. The power of these effects is so great that, acting simultaneously on any particles of a substance, they provide structural and energy changes at the molecular and atomic level. The combined effect of all factors creates a very high level of activation of all components of the substance involved in the process. The reactions are no longer diffusion controlled but become a function of the discharge phenomena with associated increases in the rates of change or reaction kinetics. This process enables a rate increase in the treatment process by many orders of magnitude thereby reducing energy use and achieving processes previously considered unattainable.
The following examples illustrate the range of capabilities of technology. Further examples are provided as separate attachments. Neither is comprehensive as the range of potential applications is so large that it is presently beyond the capacity of the existing inventors and researchers. Nevertheless, the potential uses for just the demonstrated technology applications justifies not only immediate adoption but also a comprehensive research program to explore the potential uses.

2 Gas Processing

At present, attempts to use CO_2 from emissions of Thermal Power Plants (TPP) and other fossil fuel-based generators have not found a useful application. Attempts to underground storage are possibly the best technical option but have several drawbacks.
The main sources of CO_2 growth in the atmosphere are:

1. Energy complexes (TPP)
2. Food and beverage production, including fermentation processes
3. Metallurgical industry
4. Internal combustion engines of all types.
5. Household fuel combustion.

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The first three are the major emitters of CO_2. There are no major uses for CO2 that permit sequestration of the gases or allow for recycling or replacement existing emissions. Technogenic sources of emissions of bound nitrogen, including ammonia, are much more modest, but there are also a lot of them. They include all the processes of decay. In metallurgy, the source of ammonia water is coke quenching and some others.
At present, the production of ammonium carbamate with the subsequent conversion to urea is commonly deployed. These processes are based on the reaction
$NH_3 + CO_2 \rightarrow NH_4[CO_2 \cdot NH_2] \rightarrow CO(NH_2)_2$
Ammonium carbamate after heating to above 115^0C is converted to urea.

The carbamide industry is based mainly on technologies using a stripping process as an improvement to full liquid recycling. In all processes CO_2 and ammonia are directly fed to the synthesis stage, where the process conditions are maintained at a pressure of about 140 bar and a temperature of 180 ° C.
The described method has significant drawbacks:
1. The synthesis is carried out at a temperature of up to 180^0C at a pressure of about 140 bar.
2. Multi-stage schemes are required for carbamate production.
3. The process is complex with expensive equipment.
4. There are potential technological and environmental hazards during operation although present technology has reduced these risks.
5. The process inhibits components containing impurities, such as biogas or smoke.

The **MIP/MAP** technology eliminates these drawbacks and uses raw CO_2 as the feedstock material, directly from flue gases, biogas, or similar sources.
The working area of MIP/MAP, the interaction mechanism mainly does not coincide with the traditional views. Thus, the saturation of the zone with needles creates a continuous and continuously replenishing background of energy. This means that there is no need for consumption and time to transfer the energy pulse to any point - the energy at this point is always available. The medium (NH_3, CO_2 and water in this case transform into ionized state throughout the entire volume (OH-, H +, CO-), which instantaneously arises and is continuously maintained also throughout the entire volume. Therefore, the delivery of ions to the reaction zone is not required, that is, the diffusion transfer of matter and energy takes place at the reaction or discharge site.
Consider the application of the technology to a simple standard aqueous NH_3 solution and pure gaseous CO_2. The CO_2 component of flue gases from conventional thermal power plants is also a potential source. In traditional systems, to obtain an acceptable rate of interaction of the simple components NH_3 and CO_2 they operate at a temperature of 180-200^0C, and at pressures up to 140-200 atm. These reaction conditions are now regarded as optimal for the process. If a contamination component is introduced into the working mixture - for example,

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flue gases that contain approximately 20% of CO_2, but also N_2, SO_2, etc., then the reaction efficiency between NH_3 and CO_2 will deteriorate by about 5 times with multiple side reactions. MIP/MAP equipment provides a focused mixing and reaction zone at room temperature irrespective of the phase state and concentration. By activating each component, the reactivity is increased with the synthesis of carbamate proceeding quickly and to completion. Depending on the process conditions and the component ratio, several compounds containing ammonia at various concentrations may be formed. Pure carbamate can be obtained by reacting pure gaseous NH_3 and CO_2.

If using flue gases as the CO_2 source, it is desirable to pre-purify them from several components, mainly SO_2, a major contaminant from coal and other fossil fuels.

The technological process of flue gas cleaning includes the following operations: after passing into a heat exchanger, they are cooled to a temperature of approximately 300-350 ° C. prior to feeding to MIP/MAP simultaneously with a water input. At a temperature 300-320°C, water does not react with CO2, but first reacts with SO_2 to form sulfurous acid, and then sulfuric acid. At the same time, other components of the flue gas, for example, V_2O_5 and other solid particles, are retained.

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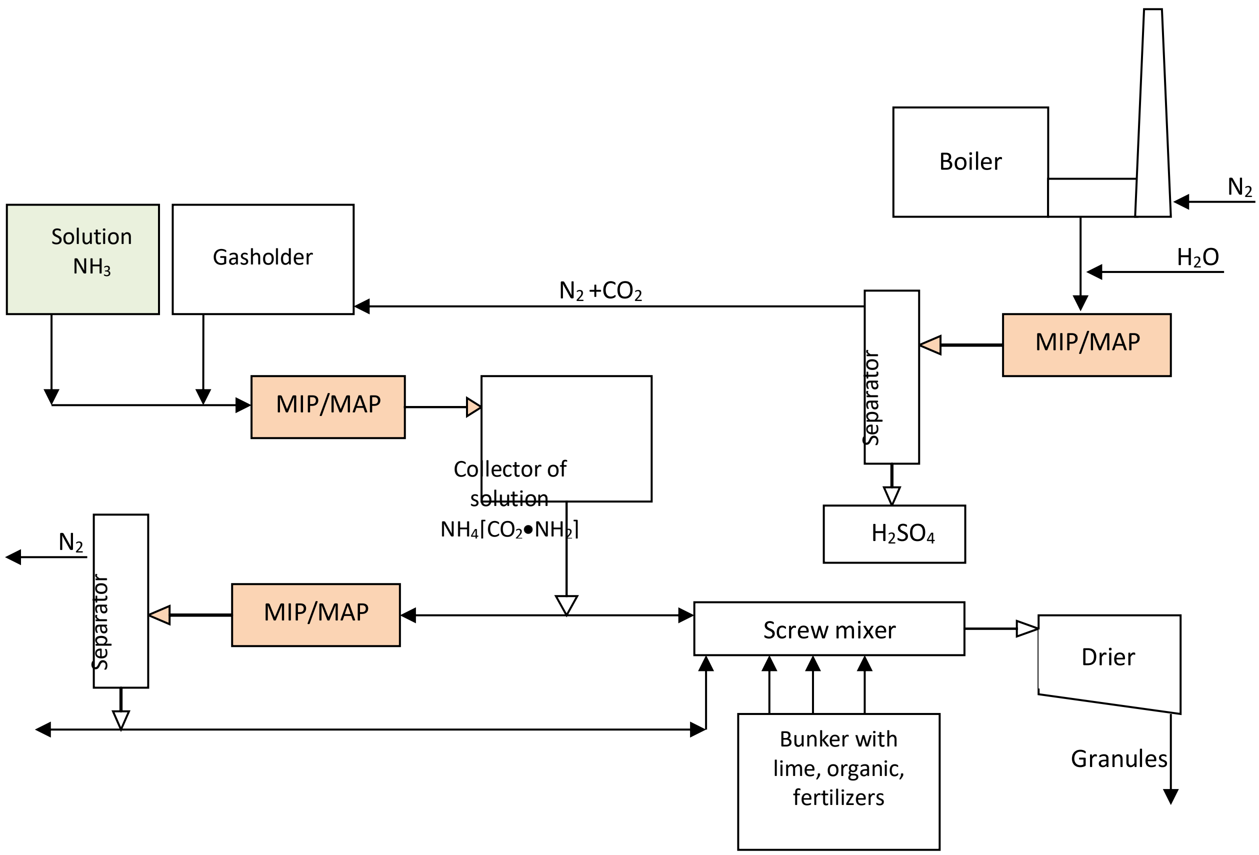

Fig. 1. Schematic of use of Plazer with CO_2 and NH_3 for production of urea and organomineral fertilizers containing nitrogen.

The production of granulated organomineral fertilizers provides several technological lines:

- Lines of ammonium carbamate synthesis;
- Lines of formation of urea or other products;
- Lines for the production of granulated organomineral fertilizers containing nitrogen;
- Lines for cleaning flue from sulfur and solid particles.

This technological line operates as follows:

From the tank, an aqueous solution NH_3 and gas mixture of CO_2 + N_2 from the gasholder are pumped through a mixer into the MIP/MAP installation in which synthesis reactions take place. The mixture is useful to heat before entering the MIP/MAP. If pure CO_2 is used, for example, from cylinders, then the gasholder is switched off. The resulting carbamate can be used as an additive to produce organomineral fertilizers containing nitrogen. To this, the

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carbamate solution is pumped to the collector with a pump in which a solution is accumulated and the molecular nitrogen from the gasholder is separated therefrom. Part of the molecular nitrogen from the flue gases in MIP/MAP interacts with water from the carrier solution NH_3, thereby increasing the yield of carbamate. Ammonium carbamate enters to the screw, into which powdered lime, mineral fertilizers, and organic materials, for example, manure, peat, etc., are fed from the bunkers. In the screw, the mixture is mixed and in the form of a viscous mass is forced through the holes in the granulating head.

Granules enter the dryer, where they quickly solidify without the use of thermal action, although the introduction of hot flue gases into the dryer is useful, but not necessary. Depending on the needs, part of the carbamate is processed into urea. For this, a part of the flow is directed to the MIP/MAP with the system for heating the mass to a temperature above 115 ° C. Further, the urea solution enters the separator, from which the solution is sent to the production of organo-mineral fertilizers containing nitrogen. From the separator, gaseous molecular nitrogen is sent to a pipe or just dropped into the atmosphere.
Most probably that in the future, the main supplier of CO_2 will be flue gases from TPP, and the fuel they consume almost always contains a lot of sulfur - a source of "acidic" rains. From the boiler, hot flue gases at a closed gate valve enter the economizer, where the gases are cooled to a temperature of approximately 300 ° C. The smoke exhaust directs the flow of gases to the MIP/MAP. At the same time, the water is supplied into MIP/MAP. At a temperature of 300° C, CO_2 does not react with water, and SO_2 forms sulfurous acid with water first, and then sulfuric acid. Simultaneously, solid components are almost completely trapped in Plazer-RF, for example, vanadium pentoxide, which is almost always present in coals, in oil or fuel oil. In the separator, the gas phase (CO_2 and N_2) is separated from the liquid (H_2SO_4 solution and its salts). Gases enter to the gasholder, and the liquid phase enters to the collector.

As a result of work, depending on the type of flue gas or other gaseous waste or emissions, the following products are formed in the described production line.

1. Urea;
2. Ammonium carbamate (or mixture of compounds of nitrogen based on NH_3);
3. Granulated organomineral fertilizers containing nitrogen;
4. Technically pure nitrogen;
5. Sulfuric acid (its salts).

Therefore, separation from the flue of CO_2 and SO_2 is a technically solvable task. SO_2 can be separated, but CO_2 remains almost unchanged in the gas composition. Flue gases become

environmentally friendly raw materials to produce products containing bound nitrogen. Moreover, a very important fact was discovered: in the working zone of Plazer-RF at elevated temperatures (50-80^0), the interaction of molecular N_2 with water was observed with formation of NH_4OH and more complex compounds containing ammonia and carbon.
It was found that when solution contains 25% of NH_3 and 75% of water, there is no water in the resulting product, but a jelly mass is formed and there is no liquid-containing component, which we consider a solution.

These facts have a great importance, since reserves of N_2 in the atmosphere are unlimited, and the amount of discharged CO_2 is estimated at many billions of tons. Therefore, the production of nitrogen-containing compounds such as ammonium carbamate and urea from free waste can solve many problems facing humanity.

Created MIP/MAP industrial installations, which have a large capacity but small dimensions, mass and energy capacity, can be installed at any TPP, in factories dealing with fermentation processes at any metallurgical enterprise.

3 Organics Processing

Developments of biological treatment processes have made major advances in aerobic and anaerobic treatment to overcome the inherent problems the processes have in treating wastewaters. The inherent disadvantages remain particularly for food processing waste systems, so that use of additional physico-chemical technologies is required post biological treatment to meet discharge criteria.

The next generation of technologies will involve only advanced physico-chemical processes that will provide full treatment in one operation, lead to major reductions in the materials produced and consumed, with lower energy use, smaller footprint, and rapid start up time. The MIP/MAP technology is the first technology that offers the broadest treatment capability covering a multiple of integrated treatment mechanisms to provide a novel advanced technical solution to meet all the requirements of lower cost of installation, operation, and maintenance.

This technology - also called micro arc processing with rotating magnetic field, combines the advantages of the physico-chemical process with other novel aspects. This overcomes the disadvantages of all existing processes and particularly the biological processes. Each unit has a capacity of up to 60 000 gals/day. It requires very little start up time(minutes), removes all contaminants to very low levels in a single pass, can be tuned for specific wastewaters, deals with trace organics and metals, and can take solids up to 5mm without changes in operation efficacy. There is no biological component, so the solids removed are only those in the water – usually at ppm levels.   These solids settle quickly and easily - unlike biological sludges, and a small high-rate settling tank is all that is required post treatment. Use of multiple units provides flexible treatment capacity.

The outcomes from these reactions are that complex solids are formed that are stable and can incorporated into recycling systems. The solids are compact low water content materials that settle quickly and can be further easily dewatered. The resultant process water is free of living microbial organisms, trace organics and heavy metals and suitable for most forms of re-use. Prior treatment for removal of gross solids and gross fats is typically less than that required in normal pre-process terms. Typical retention times in the settling tanks are 30 min to 2 hours for maximum settling and clarification, much shorter than conventional systems.

The technology can be applied to almost all forms of wastewater generated in the food processing applications areas – viz wash-down water, processing wastewater, cleaning and by-product wastewaters, fatty, oily, and greasy wastewaters and similar.   The resultant water and solid materials are suitable for discharge or reuse.

3.1 Wastewater Treatment Technology for Small Country Towns

Changes in population and regulations on discharge requirements have imposed a major burden on small towns for wastewater treatment. Existing technologies based on biological wastewater treatment are expensive, have a long lead-time and require expert operation to meet optimum operational performance. Physico- chemical processes are expensive with high ongoing operational costs and just as much sludge.

Incremental upgrading using biological systems is usually in the form of an additional digestion tank, upgrade to the inlet works and a new clarifier as well as pumps, blowers, and sludge handling facilities. These restrictions not only inhibit servicing growth in population, but they are also disincentives for industry location as well as creating a potential liability for the towns in cases of non-compliance. In addition, the byproducts such as sludge require additional treatment for handling and disposal there are additional costs in energy supply upgrades.

3.2 Options for Upgrading or New Centralized or Decentralized Systems.

The ideal system should have a small footprint that requires no major infrastructure upgrades, be quick to commission, not require chemicals and have a lower energy consumption as well as a better effluent quality for discharge or ideally for re-use.

There have been no systems being offered commercially to date in the US that can meet these requirements.

A new system that offers all these advantages is now available through MIP/MAP LLC. It overcomes all the disadvantages of existing systems and provides additional benefits at no extra cost.

The prototype has a capacity of 60 000 gals/day per unit. It requires very little start up time (hours), removes all contaminants to very low levels in a single pass, can be tuned for specific wastewaters, deals with trace organics and metals, and can take solids up to 5mm without changes in operation efficacy. There is no biological component, so the solids removed are only those in the water – usually at ppm levels. These solids settle quickly and easily - unlike biological sludge. A small high rate settling tank is all that is required post treatment. The use of multiple units is used to provide increased capacity.

The core operating principle of the technology is the passage of wastewater through an inductor that generates a rotating electromagnetic field in the presence of cylindrical shaped ferromagnetic elements (indenters). These working elements oscillate, reaching several thousand periods per second. Brief electric circuits are formed with strong currents that lead to production of many micro-arcs.

Under the influence of the rotating magnetic field the ferromagnetic elements rotate with an accompanying change in polarity. With this magnetization reversal there is a very rapid change in the discharge positions. This combination of the discharges in a rotating magnetic field provides a novel take on treatment providing a series of complex reactions.

In operation these working elements appear as local micro-impulses or micro-arcs. This action facilitates intensive mixing of the treated medium as well as dispersion of any materials. The powerful local impulses or shock actions are of sufficient power that almost all materials can be treated. This unique combination of processes leads to accelerated chemical and physical interactions with rapid kinetics for the treatment processes. These are of both macro-duration and micro-duration.

The outcomes from these multiple reactions are that complex solids are formed with oxidation of heavy metals and removal of organic materials either through polymerization, breakdown, or adsorption. The solids are compact low water content materials that settle quickly and can be further easily dewatered. The resultant process water is free of living microbial organisms, trace organics and heavy metals and suitable for most forms of re-use.

The technology can be applied to almost all forms of wastewater generated in town systems. Prior treatment for removal of gross solids and gross fats – less than 2mm is all that is required in process terms. The design of the settling tanks post treatment is assessed after the raw water is tested. Typical retention times in the settling tanks are 30 min to 2 hours for maximum settling and clarification.

Typical MIP/MAP Performance
Maximum flow per unit: 2500 gal/hr. per unit
COD – from 10,000 mg/L to less than 2mg/L in a single pass
BOD – to <1 mg/L; SS – 5000mg/L to less than 1 mg/L
Metals 100mg/L to less than 1mg/L total metals Phosphate as P - 50 to <0.05 mg/L
Nitrogen – 500 mg/L total nitrogen to less than 1 mg/L; FOGs – less than 1 mg/L

A single unit's footprint is smaller than a shipping container with greatly reduced maintenance, replacement, or operating costs. Environmental compliance becomes easier with less visible infrastructure, improved quality of treated water and less solids to treat. It also provides the potential for complete water re-use.

Energy requirements are about 40 to 50% of conventional biological systems with the footprint about 30% or less for an equivalent biological based flow treatment.

Water can be directly re-used as technical grade water or treated further for some re-use applications. Capital cost is typically 50% of comparable conventional systems or it can be leased.

3.3 Marine Waste Treatment Challenges
During the operation of ships and other marine infrastructure, polluted wastewater is formed. If discharged untreated into the marine ecosystems this causes significant ecological short- and long-term damage. Discharge of untreated wastewater is prohibited in the territorial or controlled waters of many countries with strict international standards to be complied with for signatories to IMO (International Maritime Organization). The appropriate treatment of wastewater before discharge on marine vessels presently requires special chemical and/or biological treatment systems.

On ships where space is at a premium the treatment facilities of ships occupy significant areas. More importantly, unless they are specific or limited range of biological organisms, they do not provide the required level of purification to achieve the numbers in water below the maximum

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permissible concentration of hazardous elements and compounds (MPC) and are not able to capture and dispose of, for example, heavy metals.

In the design of special purpose sea going vessels such as used by the military with specific performance requirements including maneuverability and combat serviceability, an important requirement is to reduce the weight, material consumption and energy consumption of auxiliary equipment – that includes ship's treatment facilities.

Ship operations including service and repair of marine vessels results in the following types of contamination:

- Water contaminated with oil products as well as exotic marine organisms (bilge and oily water). This can include pollution from accidental spillage of oil products during bunkering of vessels and because of various emergency situations. Cleaning large volumes of ballast water directly on-board ships while under way is further issue to reduce time in port.
- Water contaminated with by-products after welding, cutting, cleaning the hull of the vessel from deposits, old paint, chemical solvents, etc. These toxic substances get into the water during repair work. Other liquid wastes are formed during the repair work, including washing water, oily water from washing holds and tanks, motor fluids such as oil, hydraulic fluids, lubricants, and antifreeze. They mix with pulverized metal fractions, slag, shot, particles of old paint, chemicals, forming suspensions, and complicating the purification.

Purification technology and equipment is required that will provide both onshore and offshore facilities. Ideally that equipment will also provide for reductions in materials, energy consumption and energy intensity; provide versatility to treat a wide range of pollutants, as well as providing treatment of sewage for potential re-use of water for technical purposes after meeting sanitary and bacteriological quality requirements.

4 Solids processing – Inorganic and Organic

4.1 Organic

The traditional digestion process begins with bacterial hydrolysis of the input materials. Low solubility organic polymers, such as carbohydrates, are broken down to soluble derivatives that become available for other bacteria. Acidogenic bacteria then convert the sugars and amino acids into carbon dioxide, hydrogen, ammonia, and organic acids. These bacteria convert these resulting organic acids into acetic acid, along with additional ammonia, hydrogen, and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide. The methanogenic archaea populations play an indispensable role in anaerobic wastewater treatments.

The four key stages of anaerobic digestion involve hydrolysis, acidogenesis, acetogenesis and methanogenesis. The overall process can be described by the chemical reaction, where organic material such as glucose is biochemically digested into carbon dioxide (CO_2) and methane (CH_4) by the anaerobic microorganisms viz: $C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$

Under typical circumstances, hydrolysis, acetogenesis, and acidogenesis occur within the first reaction vessel. The organic material is then heated to the required operational temperature (either mesophilic or thermophilic) prior to being pumped into a methanogenic reactor. The initial hydrolysis or acidogenesis tanks prior to the methanogenic reactor can provide a buffer to the rate at which feedstock is added.
The anaerobic digestion process can be inhibited by several compounds, by affecting one or more of the bacterial groups responsible for the different organic matter degradation steps. The degree of the inhibition depends, among other factors, on the concentration of the inhibitor in the digester. Potential inhibitors are ammonia, sulfide, light metal ions (Na, K, Mg, Ca, Al), heavy metals, some organics such as biocides including chlorophenols, halogenated aliphatic, N-substituted aromatics, and long chain fatty acids. These do not occur in significant concentrations in normal wastes only in some industrial wastes.
The most important initial issue when considering the application of anaerobic digestion systems is the feedstock to the process. Almost any organic material can be processed with anaerobic digestion. If biogas production is the aim, the level of putrescibles is the key factor in its successful application.[47] The more putrescible (digestible) the material, the higher the gas yields possible from the system.

MIP/MAP interventions Advantages and Optimization

The actions of PLAZER-RF should be as part of the inflow process into a digester:

- Break up solids containing bioavailable materials including microbial cells;
- Remove inhibitor compounds such as long chain fatty acids and
- Commence hydrolysis reactions or reduce large MW compounds to smaller easily digestible materials;
- Reduce the HRT
- Increase the methane recovery

- Ensure color and odor removal
- Leave a solids residual that is easy to manage.

The microbial populations of the digesters are dynamic and respond to the inputs sources over time depending on the substrate compositions. Even with a constant input the final equilibrium microbial population may be completely different from the starting composition without any change in gas composition or residual biosolid dewaterability.

However, the critical factors that need to be optimized for an operator are:

- Gas compositions – ideally more than 70% methane, low sulfur, and the balance of carbon dioxide.
- Retention time in the digester – the longer each individual step takes the larger the hydraulic retention time (HRT). This is typically 15 to 30 days - some plants have achieved a 5-day HRT for easily digested materials.
- Nature and mass of the residual Biosolids. – These are dependent on the microbiome of the digester and the input materials. The critical factor is the ease of dewatering and resultant dry solids and composition of the leachate.

Table The influence of MIP/MAP processing on particle size of livestock wastes

Process	Moisture %	Fractional composition. %						Note
		3 mm	2 mm	1 mm	0.5 mm	0.25 mm	< 0.25 mm	
Source untreated	93.27	7.38	5.78	18.59	4.76	4.89	58.6	
After processing	95.03	0.29	0.21	12.59	5.94	6.06	76.91	Flow rate 4.5 m^3/h.

The impact of the particle size on gas production is significant as well as on the HRT.

Table The influence of additives and MIP/MAP processing on bacteria in livestock wastes (*E-coli and Staphylococcus aureus).* Processing Time 3-10 sec.

Material	**Additive**		**E-coli**	**S. aureus**	**Check Time (days)**
	View	**Quantity**			
Source - untreated	–	–	10^6	10^6	1
After processing	Kon	1 L/t	10^2	10^2	1
After processing	Kon	3 L/t	10 °	10 °	1
After processing	Kon	5 L/t	0	0	1
After processing	Ammonia	30 L/t	0	0	3
After processing	Ammonia	5 L/t	0	0	3
After processing	Formaldehyde	10 L/t	10	10	1
After processing	Formaldehyde	25 L/t	0	0	1

Similarly, the disinfection achieved after processing indicates a high level of removal of indicator bacteria.

Post Digestion Treatment

Residual COD/BOD of the decant liquor. This is typically 2000 to 5000mgC/L that requires a second pass treatment using an aerobic treatment. In STPs this is usually passed back to the headworks of a STP but could be PLAZER treated. Preliminary studies have shown that polymerization of the complex organics left occurs with greatly lowered COD after treatment.

A post AD treatment that could reduce the COD of the residue to less than 2 mg/L in a single pass may be able to be provided by PLAZER as well as biologically inactive outputs – so called disinfection, without any adverse compounds such as NDMA and chlorinated organics such as

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THMs. Removal of P and N would be advantageous as part of the settling process would add benefits.
These are not controllable in the usual sense but will depend on the multiple factors outlined above.

4.2 Inorganic Wastes, Metal processing byproducts and tailings wastes.
This document will provide perspectives on the application of micro-pulse micro-arc processing (MIPMAP) in rotating electromagnetic fields known as PLAZER for disintegrating minerals, processing mineral waste dumps tailings and metal processing waste sludges to capture valuable components from virgin and depleted ores. The process provides lower capital and operating costs and higher rates of recovery. The process design and operations can be incorporated into existing plants or be used as a separate processing feed.

The wide variety of ores used in the mineral processing industry does not allow a simple prediction of the possible results from processing with the PLAZER system. Therefore, it is essential to undertake a full study of the composition of the ore (mineralogy and physicochemical properties, composition) to select the optimum size for target mineral recovery. This is no different to the development of the usual mineral processing practice.

Traditional technologies such as initial grinding, milling, floatation, solvent chelating or acid leaching followed by precipitation are multi-stage processes with intensive use of chemicals, energy, and other materials such as water. An additional issue is the treatment of wastewater and disposal of the treated water and byproducts. All traditional operations requiring direct contact of the ore with a solution are also relatively slow and of low efficiency.

MIP/MAP and CHOPER equipment can be used to accelerate the dissolution and leaching processes and to increase the level of extraction of the target components from the ore without increasing the residues. The effectiveness of this process with this non-traditional technology and processing also enables profitable recovery of target elements from low grade ores, tailings dump and mine waters.

Traditional processes for grinding of ores and concentrates in ball and rod mills are time consuming and energy intensive. The grind output size is limited to several hundred microns unless multiple passes are used to fully expose finely disseminated ores. With the CHOPER **+ MIP/MAP** complex, most minerals can be milled to several microns in a single pass. This opens new possibilities for a more complete extraction of minerals. The time for production is lowered with lowered use of energy, water, and reduced noise. For example, MIP/MAP is capable of producing powders from 500 microns particles to fractions of 44 microns or less within 20-50 seconds as shown in the table below with iron ore.

Powder size Fe_2O_3 after milling 500-micron material with Plazer-RF (% composition of resultant powder).

	Fractions, microns													
	30-100	20-30	14-20	10-14	8-10	6-8	4,3-6	3-4,3	2-3	1,4-2,0	1-1,4	0,43-1	0,04-0,43	Σ ≤ 1
Single pass from 500 µm	**27,91**	**1,58**	**0,79**	**1,57**	**1,05**	**2,35**	**2,62**	**2,59**	**3,36**	**2,83**	**24,41**	**20,3**	**8,64**	**28,94**
After Plazer 3 min.	**Not detected**			**8,13**	**4,38**	**3,92**	**3,47**	**3,0**	**2,96**	**12,08**	**12,44**	**16,17**	**33,45**	**59,62**

The above data indicates that MIP/MAP equipment can provide uniform fine powders of less than 1 micron in short time frames.

MIP/MAP also enhances metal recovery particularly at very low levels using hydrometallurgical cementation processes. Experimental evidence – shown below, has established that in the presence of iron, ores processed with PLAZER-RF provide for high levels of recovery of nickel copper, gold, silver, arsenic, platinum, and other metals from solution at a rapid rate.

There is a noticeable speed up of chemical reactions, a reduction in the consumption of additives, the consumption of electricity, and reduction in associated labor costs.

1. Significant acceleration of settling/precipitation of the solid phase (95% drops in the first 5-8 minutes) The sediment and solution above it have a clear interface.
2. Increased output of valuable components.
3. Collection (separation) of valuable components from dumps using the same equipment.
4. Obtaining finely ground quartzite suitable for use as foundry sands – 'Marshallit', as valuable by-product.
5. There is no need to use high toxic regents for extraction of precious metals, including mercury and cyanide.
6. Decrease in the volume of sedimentation tanks (by a factor of about 10), as well as the number of mixers, filters, auxiliary tanks.
7. Suitable for deployment as mobile treatment sites, greatly reducing the time for development of the whole production.
8. Areas are self-contained with zero discharge production that prevents discharges, the loss of potentially valuable components and complies with environmental regulations.

Performance capacity of one set of the basic equipment (**Plazer-RF** reactor and grinder **Plazer-RC**) reaches 35 t/day for ore or 200 m^3/day of pulp slurry. Increased production is achieved with multiple units.

The equipment based on this innovative technology is very suitable for processing small deposits of valuable elements such as tungsten. In the absence of supporting infrastructure such as roads, major plant, power, and equipment these mobile equipment sites with **Plazer-RF & Plazer-RC** can be easily delivered to site and removed when it is finished with little environmental impact.

5. Discussion

5.1 Advances in Treatment Processes

The range of traditional physico-chemical treatment options is large ranging from simple physical separation through to advanced oxidation and cold plasma technologies.

The limitations of each of these methods are that each technology by itself generally provides only partial treatment for any wastewater and with changes in input composition they can result in incomplete treatment of the water. Such failure leads to either restrictions in the potential use of the water or non–compliance with discharge criteria or permitting conditions.

With a few exceptions, the poor level of development of these technologies for large-scale domestic and industrial wastewater treatment has made the development of aerobic and more recently anaerobic biological methods the method of choice for most systems. Investment in research and development led to advances in treatment that resulted in biological processes and their developments becoming the technology of choice for most small and large-scale treatment systems.

There are limitations to these systems. More stringent discharge criteria have led to the need for complex post primary or secondary reactor systems usually involving a physico-chemical process. This has led to a re-evaluation of physico-chemical systems as options for large treatment facilities. The use of these for post biological treatment example as disinfecting agents including UV, chemical precipitation of nutrients, ozone/UV for trace organics and catalytic technologies to remove pathogens and trace metals has led to a new awareness of their capabilities.

Emerging issues such as non–removal of some pathogenic organisms, excess sludge production and lack of removal of trace organics and inorganics and increased investment in capital works to meet increasingly stringent water quality criteria have accentuated this re-evaluation of the fundamentals of biological systems.

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Various technical solutions have been successfully developed for additional or add-on processes to deal with some of these issues. For example for sludge treatment – CAMBI (https://www.cambi.com/) or use of granular sludges (http://www.aquanereda.com/) , increased use of anaerobic treatments for a broader range of carbon loadings and the inclusion of membranes for both separation of solids and retention of biological biomass[2] have led to improvements in processing to overcome some of these issues. Capture of more valuable minor components such a nutrient such as in the form of struvite or nitrogen removal by processes such as Anammox have led to a resurgence of interest in the biological processes and their use for water and wastewater treatment.

Despite all these advances the biological processes have major inherent disadvantages including:

- Capital intensity
- Process intensification is difficult
- Long and complex construction times
- Difficulties with operation and automation/instrumentation is expensive
- Large footprints
- Odor and nuisance organisms – midges for example
- Sensitivity to inflow variations
- Long lead times for commissioning and start-up
- Variable output quality
- Inability to deal with metals or and the increased range of trace organics of low biological reactivity
- Slow overall processing rates
- Requirements for physico-chemical post biological treatments for best quality effluents
- Disrupted easily by biocides, foreign materials and dilution of food sources
- Energy intensity with low energy efficiency
- Difficulty to upgrade in terms of capacity or treatment levels.

5.2 Advances in physico-chemical treatments.

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The use of physico-chemical treatment in the post biological processes has led to a new acceptance of the efficacy of these methods. There have been big increases in efficiency in, for example ozone production and its safe use, and UV ozone methods are a method of choice for trace organics in many cases. Scaling of these systems to cope with flows of up to 100 million gallons/day has proven the fundamentals of the processes and their design.

Use of newer membranes including ceramic materials rather than chemical precipitation has allowed a greater use of technologies that don't cope with suspended solids. Their energy requirements are still relatively large and capital investment for large systems compared with biological systems is not shown to be widely accepted except for specific applications. Even then regulatory approval can be restrictive if there are not proven examples for the specific application.

The use of physico-chemical systems is regarded as the next 'holy grail' of water and wastewater treatment by several major industry groups with significant resources being devoted to a range of technologies. These include UV/ozone, chlorine and its derivatives, electrochemical methods using novel electrodes and linking these with ceramic membranes. Cold plasma and related technologies appear to be the next generation of treatment technologies.

Of the newer technologies for full treatment – as distinct from post or tertiary treatment, the cold plasma technology is one of the most interesting with some key aspects for its uses. These include rapid settling of solids post treatment, removal of trace organics and high levels of disinfection. There are no off gases produced and the waste is only that of the material in the solution, there is no additional sludge or biomass involved. The technology has been used in the food processing industry for pathogen removal with a high level of success. Scaling of this technology to give large treatment capacity at low energy consumption has not been demonstrated so far.

A recent emerging technology called micro arc processing with rotating magnetic field [7] combines the advantages of the physico-chemical process with some other novel aspects. This overcomes the disadvantages of existing physico-chemical processes and particularly biological processes. It is a major advance over cold plasma technologies while appearing to have all the advantages of that technology.

It has gone beyond piloting stage to pre-production prototype with a capacity of $10m^3$ per hour (60 000 gals/day). It requires very little start up time(minutes), removes all contaminants to very low levels in a single pass, can be tuned for specific wastewaters, deals with trace organics and metals, and can take solids up to 2mm without changes in operation efficacy. There is no biological component, so the solids removed are only those in the water – usually at ppm levels. These solids settle quickly and easily - unlike biological sludges, and a small high-rate settling tank is all that is required post treatment.

At present scaling up beyond the existing throughput is not possible but models for development and design purposes are being developed and proposed. Use of multiple units is feasible to provide increased capacity.

The core operating principle of the technology is the passage of wastewater through an inductor that generates a rotating electromagnetic field in the presence of cylindrical shaped ferromagnetic elements (indenters). These working elements oscillate, reaching several thousand periods per second. Brief electric circuits are formed with strong currents that lead to production of many micro-arcs.

Under the influence of the rotating magnetic field the ferromagnetic elements rotate with an accompanying change in polarity. With this magnetization reversal there is a very rapid change in the discharge positions.

This combination of the discharges in a rotating magnetic field provides a novel take on treatment providing a series of reactions that combine:

a. Particle Dispersion;
b. Water ionization with separation of H+ and Hydroxyl Group OH-;
c. Weakening of intermolecular and interatomic bonds;
d. Oxidation/Reduction reactions (redox) by free radicals;
e. Magnetic field sustaining processes with highly ionized entities;
f. Magneto Hydrodynamic shocks comparable to cavitation processes or hydro-acoustic effects,
g. Intensive mixing of liquid phase
h. Localized thermal effects.

In operation these working elements appear as local micro-impulses and micro-arcs. This action facilitates intensive mixing of the treated medium as well as dispersion of any solid materials. The powerful local impulses or shock actions are of sufficient power that almost all materials can be treated.

This unique combination of processes leads to accelerated chemical and physical interactions with rapid kinetics for the treatment processes. These are of both macro-duration and micro-duration.

The outcomes from these complex reactions are that complex solids are formed with oxidation of heavy metals and removal of organic materials either through polymerization, breakdown, or adsorption.   The solids are compact low water content materials that settle quickly and can be further easily dewatered. The resultant process water is free of living microbial organisms, trace organics and heavy metals and suitable for most forms of re-use.

The technology can be applied to almost all forms of wastewater generated in the marine applications areas – viz bilge water, on board wastewater, cleaning and dry dock wastewaters, oily wastes and similar. Prior treatment for removal of gross solids – less than 5mm is all that is required in process terms. The design of the settling tanks post treatment will be assessed after the raw water is tested. Typical retention times are 30 min to 2 hours for maximum settling and clarification.

This technology is described in a brief technical bulletin provided by PLAZER –RF (attachment 1).

While developments of biological treatment processes have made major advances in aerobic and anaerobic treatment to overcome the problems the processes have raised in treating wastewaters, the inherent disadvantages remain particularly for marine based systems.

The next generation of technologies will involve advanced physico-chemical processes that will provide full treatment in one operation, lead to major reductions in the materials produced and consumed, lower energy, smaller footprint, and rapid start up time. Of these the PLAZER-RF technology offers the best and a novel technical solution in this area of technology.

6. Conclusion

The MIP/MAP technology uses a completely different method of generation of multiple forces and reactive agents to treat materials. This is disruptive technology unlike any presently in use for this purpose.

The technology provides for the passage of material – gas, solid or liquid, through a tubular reactor in which an inductor generates a rotating electromagnetic field. Ferromagnetic elements(indenters) that are needle shaped are placed in the working cylindrical zone of the inductor/reactor. The working elements oscillate, reaching several thousand periods per second. For a short time, electric circuits are formed in which strong currents arise to form temporary circuits. When these circuits break, many micro-arcs arise. When moving, the working bodies continuously emit powerful local micro-impulses and micro-arcs – MIP/MAP. This facilitates intensive mixing of the media being treated and the dispersal of materials. The high-powered local shock impulse action from the chain breaks acts on the material being treated.

Several effects are generated that combine with the local thermal and mechanical phenomena that occur when the working bodies interact with a substance. The power of these effects is so great that, acting simultaneously on any particles of a substance, they provide structural and energy changes at the molecular and atomic level. The combined effect of all factors creates a very high level of activation of all components of the substance involved in the process. The reactions are no longer diffusion controlled but become a function of the discharge phenomena with associated increases in the rates of change or reaction kinetics. This process enables a rate increase in the treatment process by many orders of magnitude thereby reducing energy use and achieving processes previously considered unattainable.

Several examples are provided in the treatment of gases, liquids – fresh and saline, solid organics, and solid and liquid wastes in inorganic material processing. This range of potential applications is so large that it is presently beyond the capacity of the existing inventors and researchers to investigate all applications. Nevertheless, the potential uses for just the demonstrated technology applications justifies not only immediate adoption but also a comprehensive research program to explore the potential uses.

TECHNICAL SUPPLEMENT: PLAZER RF TECHNOLOGY

SUMMARY

The purpose of this is to document the performance of a novel advanced technology for treatment of wastewater, water and other solids for reuse and groundwater injection without the production of disinfection by-products.

The advantages of this technology include low capital and operating costs compared with any alternative process, low by-product production, treated water that is suitable for direct re-use and by-products that are suitable for easy re-processing for nutrient and other resource recovery.

THE EQUIPMENT AND TREATMENT PROCESS

The equipment provides a continuous flow through treatment of up to $10m^3$/hr. for each unit. Pretreatment requires grinding or settling to remove gross solids (solids to less than 2mm and preferably around 500 microns) and post treatment with settling/filtration to remove solids. Further treatment for re-use may be required to meet local re-use criteria.

The core operating principle of the technology is the passage of wastewater through an inductor that generates a rotating electromagnetic field in the presence of cylindrical shaped ferromagnetic elements (indenters). These working elements oscillate, reaching several thousand periods per second. Brief electric circuits are formed with strong currents that lead to production of many micro-arcs.

Under the influence of the rotating magnetic field the ferromagnetic elements rotate with an accompanying change in polarity. With this magnetization reversal there is a very rapid change in the discharge positions. As a result of these almost continuously emitted power impulses, a large force is applied to the environment (15 to 20 tons/mm^2), acting over a small distance. In water the extent (or range) of interaction of these pulses is several times larger than in solid phase operations.

In operation these working elements appear as local micro-impulses and micro-arcs. This action facilitates intensive mixing of the treated medium as well as dispersion of any solid materials. The powerful local impulses or shock actions are of sufficient power that almost all materials can be treated.

As a result of these interactions the wastewater to be treated is exposed to the following effects:

a. Particle Dispersion;
b. Water ionization with separation of H+ and Hydroxyl Group OH-;
c. Weakening of intermolecular and interatomic bonds;
d. Oxidation/Reduction reactions (redox) by free radicals;
e. Magnetic field sustaining processes with highly ionized entities;
f. Magneto Hydrodynamic shocks comparable to cavitation processes or hydro-acoustic effects,
g. Intensive mixing of liquid phase
h. Localized thermal effects.

This unique combination of processes leads to accelerated chemical and physical interactions with rapid kinetics for the treatment processes. These are of both macro-duration and micro-duration.

The outcomes from these complex reactions are that complex solids are formed with oxidation of heavy metals and removal of organic materials either through polymerization, breakdown, or adsorption. The resultant water is free of living microbial organisms, trace organics and heavy metals and suitable for most forms of re-use.

The separated solid waste stream can be further treated for beneficial reuse or resource recovery, especially nutrients. Note that the solids removed are only in the original wastewater – there are no added chemicals or biological by-products or sludges. (In some PLAZER-RF systems treating very high loads of metals, pH adjustment may be required).

Pretreatment:
Solids to be less than 2mm or preferably 500 microns.
Gross solids to be removed.

A single unit's footprint is smaller than a shipping container with greatly reduced maintenance, replacement, or operating costs.
Environmental compliance becomes easier with less visible infrastructure, improved quality of treated water and less solids to treat. It also provides the potential for complete water re-use.

Economic and Financial Benefits
This technology has the following financial advantages when compared with the BAT for comparable processes:

1. The initial capital costs are reduced by up to 80% and are typically 50% lower;
2. The footprint is similarly reduced by an equivalent amount with reductions in building sizes, land acquisitions and buffer zones;
3. Land requirement for associated buildings and external infrastructure can also be reduced by up to 80% as holding ponds and secondary processing equipment is removed;
4. Associated process equipment such as motors, compressors, pumps is reduced by up to 60%;
5. Personnel based operation and maintenance (O&M) costs are reduced due to the simplified processes, the self-contained equipment and less hazardous processes;
6. Electric power costs will be reduced by up to 70%;
7. No extra biosolids are produced in this process. Organic and inorganic based solids are separated out for reuse and reprocessing. This can be an additional income stream depending on the waste composition.

The actual benefits will depend on the site and treatment characteristics. The figures quoted here are for typical comparable plants that are biological or biological/chemical treatment systems for advanced secondary or tertiary treatment.

Environmental Benefits
The systems are fully enclosed treatment processes that require no oxygen inputs and no biological inputs. They are not a reservoir for antibiotic resistance, and after the initial(conventional) solids screening there is no exposure to the atmosphere and no production of odors or development of nuisance organisms such as midges. The biological fraction of solids residues is suitable for direct use as fertilizers and are stable.

The technology provides the first opportunity for zero discharge processing of domestic and industrial wastes with on-site or local re-use. Alternatively discharge of the water into the environment permits the release of low nutrient water without the risk of eutrophic waterbodies or the need for significant flushing or dilution flows.

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Developing the concept of a zero-discharge economy.

The ideal economy should be self-sustaining and resilient.   An ability to adjust to changes in population, economic growth, natural hazards and variability in production and demand requires a level of sophistication at all stages of production, processing, and waste management.

A major limitation is likely to be the use and re-use of water and the optimization of all systems using the best available technology to approach the concept of zero waste.   The PLAZER technology is an example of an example of a disruptive technology that can not only assist with the processing of liquid wastes but can assist with treatment of many mining and industrial wastes, some air pollutants and solid biological wastes.

The technology is based on a major scientific and technological breakthrough - Micro-pulse Micro-arc processing (MIPMAP) in rotating electromagnetic fields. This technology enables the conversion of organic and inorganic sludges, mine tailing accumulations, sewage from all sources, industrial waste including many types of hazardous waste (organic and non-organic) and even construction waste, into raw materials for reuse with minimal processing.

For example, organic waste is quickly converted into fertilizer as high-quality organic fertilizer, removing chemical impurities elements to low levels. Similarly non-organic waste into metal oxides or stable chemical components, materials for use as high quality construction materials (silica, alumina, mixed oxides etc.). The separation method using settling or floatation provides a low-cost high purity product.

MIPMAP can potentially enable us to reprocess most types of waste into major sources of key materials, while minimizing wastes from many existing industries thereby preventing new accumulations.

The need to conserve and recycle our water reserves is critical to the industrial and socioeconomic economies. With cost effective and technological efficacy for capture and recycling of pollutants this will prevent them from reaching streams, rivers, and lakes. It also enables water re-use.

The incorporation of MIPMAP type technologies into existing systems will allow us to approach the ideal of zero discharge and total re-use.

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