Bioremediation & Waste Management of Hazardous Petroleum and Petrochemical Hydrocarbon Wastes with Saion Biotechnology

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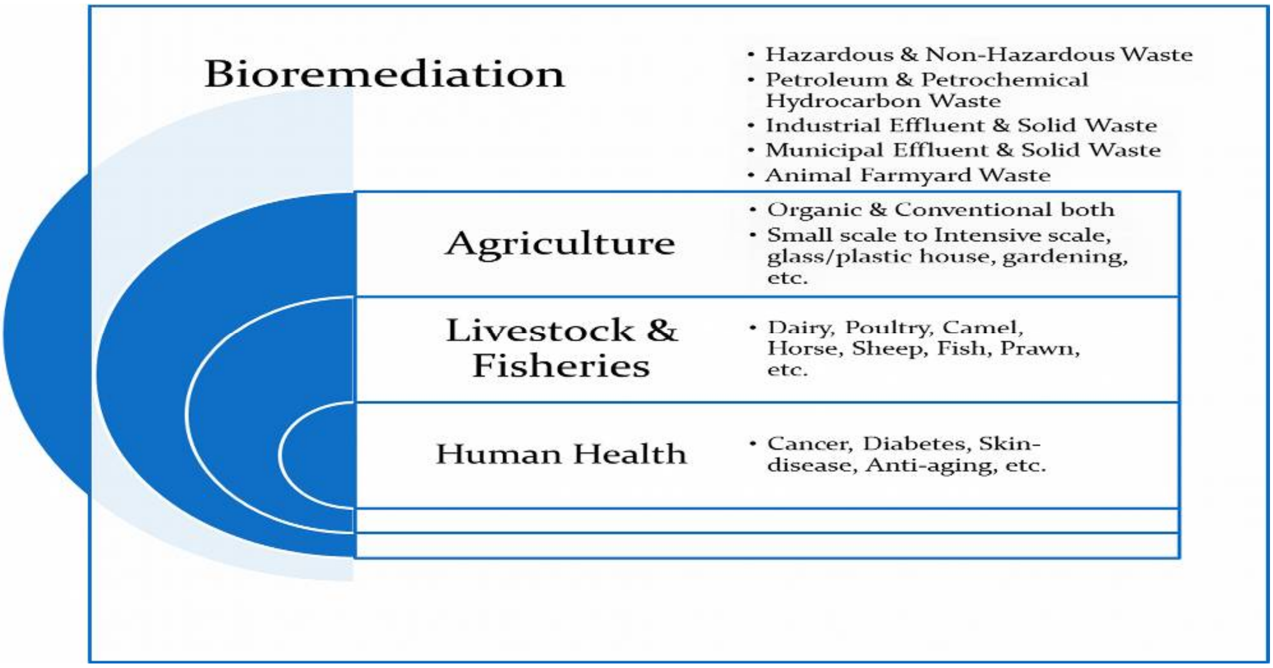
Introduction

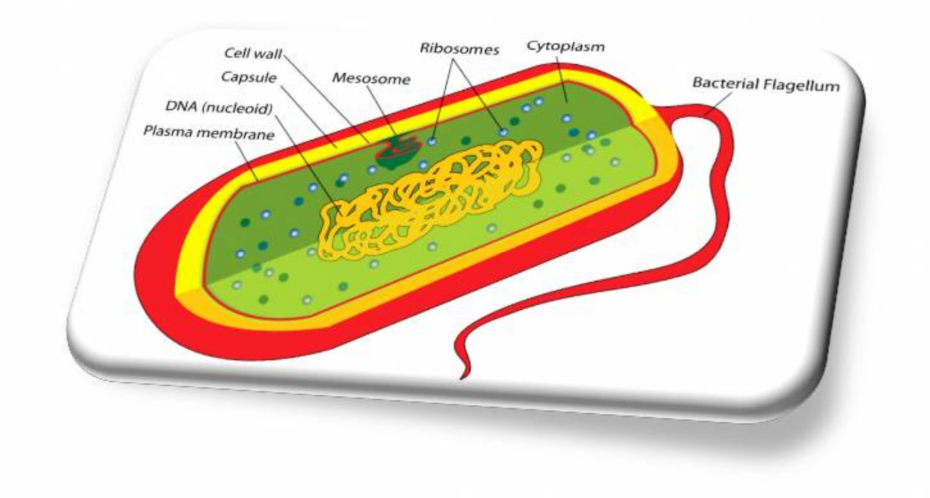
Bioremediation of Hydrocarbons (TPH), Heavy Metals, Polychlorinated biphenyls (PCB) Spent Caustic, Phenol, Sulfur, MTBE, BTEX, NORM, Dioxins, NOx, SOx and other contaminants are everyday topics of petroleum and petrochemical industries. Chemical, Non-chemical, mechanical, and biological approaches are adopted world-wide to tackle these environmental issues. However, secondary contamination and treatments for secondary wastes are a sky high challenge for industries; environment protection agencies and environmentalists, where a huge cost and time is dumped. Man-made developments, resulting environmental problems, limitations to solve these problems, have lead us to considering going back to NATURE and find hints and solutions to fix these man-made problems. Biological treatments recently have been of full interest in all sectors, due to their efficiency, low cost and high performances.

Saion Biotechnology is one of those result oriented proven technologies. This technology was developed in late 70's in Japan. It is different from other technologies due its composition of aerobic and anaerobic microorganisms and their applications. Normally, aerobic and anaerobic microorganisms cannot exist together in the same environment, but Saion Biotechnology has made it possible where both survive on each other and complement each other for co-existence and prosperity. There is no genetically modification in this technology, all microorganisms are isolated from nature, and most of them are food-grade and exist in almost all environments. Therefore, the formulas are environmentally friendly, easy to handle, cost-effective with high performance. These isolated microorganisms are capable to guarantee the existence and performance of those microorganisms which are essential and beneficial in bioremediation, as given in Table 1.

Saion Biotechnology works under a harmony and combination of different methods, i.e. biological degradation, phytoremediation, mycoremediation, wet air oxidation, redox, fermentation, activated carbon filtration, to achieve maximum performance of bioremediation.


HQ Japan
Argentine
Brazil
Egypt
India
Indonesia
Kazakhstan
Oman
Philippines
Thailand
Turkey
Japan (HQ)
Australia
China
Germany
Holland
Hong Kong
Malaysia
Pakistan
Saudi Arabia
Singapore
Taiwan
Tunisia


Bioremediation
• Hazardous & Non-Hazardous Waste
• Petroleum & Petrochemical Hydrocarbon Waste
• Industrial Effluent & Solid Waste
• Municipal Effluent & Solid Waste
• Animal Farmyard Waste
Agriculture
• Organic & Conventional both
• Small scale to Intensive scale, glass/plastic house, gardening, etc.
Livestock & Fisheries
• Dairy, Poultry, Camel, Horse, Sheep, Fish, Prawn, etc.
Human Health
• Cancer, Diabetes, Skin-disease, Anti-aging, etc.



1. **Table 2. Composition of a Microbial Cell** [C:N:P (110:10:4)]

Carbon ©	50%	Sodium (Na)	1%
Nitrogen (N)	14%	Calcium (Ca)	0.5%
Oxygen (O)	20%	Magnesium (Mg)	0.5%
Hydrogen (H)	8%	Chloride (Cl)	0.5%
Phosphorous (P)	3%	Iron (Fe)	0.2%
Sulfur (S)	1%	Other	0.3%
Potassium (K)	1%		

Microorganisms recognize hydrocarbons, their constituent by bio-surfactants and bio-emulsifiers, attack them and use as source of energy and carbon. At the same time produce enzymes which attack hydrocarbon molecules. Enzymatic redox reaction reduces heavy metals as part of metabolic process both in aerobic and anaerobic condition. Hydrogen releasing compounds such as lactic acid, through biological interaction, provide carbon source, undergo biological transformations and generate hydrogen, and enzymatically the reduction in heavy metal occurs. In other words, microorganisms can catalyze redox reactions by a combination of several mechanisms; including enzymatic extra-cellular reduction, non-metabolic reduction by bacterial surfaces and intra-cellular reduction and precipitation. Both eukaryotic and prokaryotic cells can actively transport heavy metals across their cell membrane to reduce heavy metals.

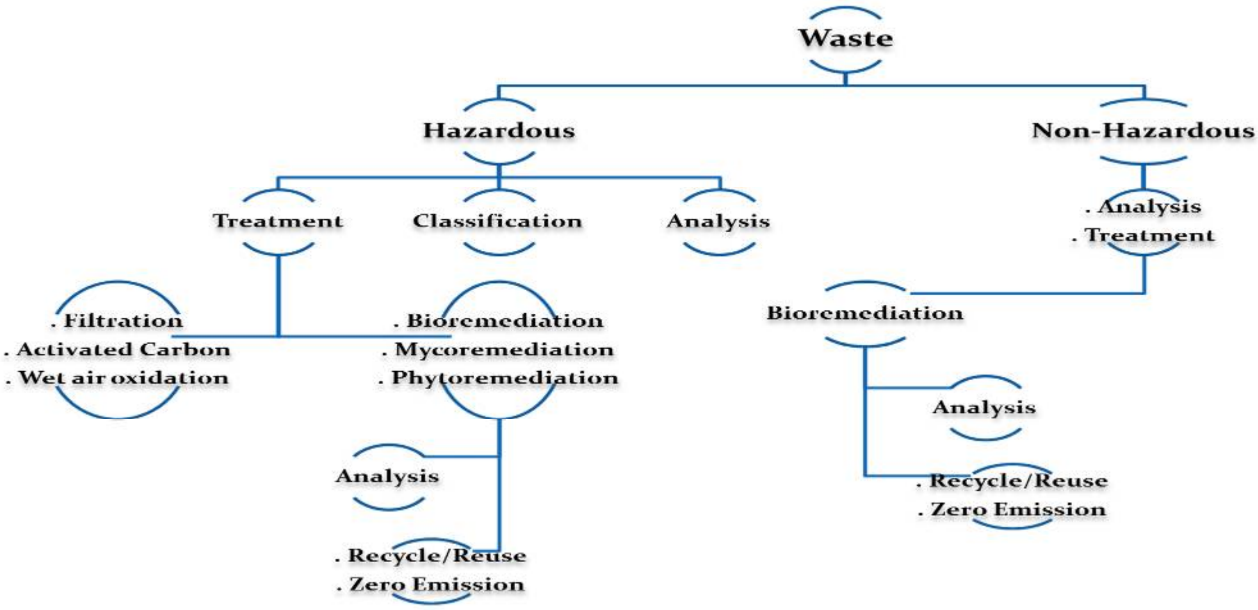
For example, *Cryptanaerobacter phenolicus* produces benzoate from phenol via 4-hydroxybenzoate.

Rhodococcus phenolicus is able to degrade phenol as sole carbon source. *Tyrosinase* enzyme is fast in oxidation of phenol. Microorganisms can neutralize toxins by converting the halogens to harmless compounds like salts. Microorganisms enhance bio-augmentation which enhances bioremediation process. Microorganisms oxidize sulfides and mercaptans to sulfates through wet air oxidation.

Microorganisms deodorize VOCs, reduce COD, BOD, TOC, phenols, oils and polymers and breakdown toxic hydrocarbons. Anaerobic microorganisms use other electron acceptors like nitrate, iron or sulfate to yield energy and continue bioremediation process.

2.

Procedure:



Bioremediation progress

Medium to be monitored	Purpose	Sampling frequency	Parameters to be analyzed
Pretreatment sampling	Establish a base line	Once before starting the soil treatment cell	TPH, bacteria population, soil sieve analysis (grain size distribution), constituent concentrations, & pH
Soil in the cell.	Determine constituent degradation and biodegradation conditions	Monthly during the operation	Bacterial population, constituent concentrations, pH, ammonia, phosphorus, moisture content, other rate limiting conditions
Air extracted or collected from the cell.	Determine constituent degradation and biodegradation conditions	Weekly during first 3 months then monthly	CO_2, O_2, CH_4, H_2S, VOCs.
Air	Site personnel and population health hazards	Twice during the first two weeks of operation, quarterly thereafter	Volatile constituents, particulates
Runoff water	Soluble or suspended constituents	As needed	Hazardous constituents
Soil beneath the cell	Migration of constituents	Quarterly or twice per season	Hazardous constituents
Groundwater monitoring wells	Migration of soluble constituents	Monthly	Hazardous, soluble constituents
Project closeout	Verification	Once at the end of the project	TPH, bacteria population, and constituent concentrations

Basic Analytical Methodologies

Parameter	Method
TPH	USEPA Method 418.1
TCLP	USEPA Method 8021
Microbe counts	Colony-forming units (CFU) and colony-utilizing population (CUP).
Soil physical analysis	Soil sieve analysis (grain size distribution)
pH	Direct reading instrument
BTEX	USEPA Method 8020.
Other	As per PME standards

Basic Equipment used for identification of hydrocarbons & remediation mapping

1	GIS	Geographic information system
2	AS	Air stripping
3	GLC	Gas liquid chromatograph
4	FID	Flame ionization detector
5	Toxmap	Toxmap
6	HACH	Hach spectrophotometer for turbidity

Results:

Zero emission achievements:

Parameters	Before	After	Change
N	0.83%	6.8%	719% (↑)
P	0.0584%	0.0748%	28% (↑)
K	0%	0.0384%	4% (↑)
OM	65.1%	5.1%	92% (↓)
Ba	2570ppm	191ppm	93% (↓)
Pb	200ppm	42ppm	79% (↓)
Fe	34430ppm	8686ppm	75% (↓)
Zn	1440ppm	382ppm	73% (↓)
Ni	90ppm	26ppm	71% (↓)
Mn	220ppm	103ppm	53% (↓)
Cu	50ppm	21ppm	58% (↓)
Cr	24ppm	13ppm	46% (↓)
As	29ppm	18ppm	38% (↓)

Table 1. TPH Value before Treatment

Sample Location	Sample Quantity (kg)	TPH value (mg/kg)	TPH value (average)
Kandanwari Plant	100	1675	1292
Sawan-5	50	795	
Ex-waste pit	50	1025	
Total Sample	200		

Table 2. (after 4 weeks)

Trial 1			Trial II		
TPH Value (mg/kg)	Humidity Content (%)	Value Reduction (%)	TPH Value (mg/kg)	Humidity Content (%)	Value Reduction (%)
356	14.1	72.45	298	16.87	77

Table 3. (after 8 weeks)

Trial 1			Trial II		
TPH Value (mg/kg)	Humidity Content (%)	Value Reduction (%)	TPH Value (mg/kg)	Humidity Content (%)	Value Reduction (%)
297	16.12	77	83.4	18.7	93.5

Radiation & Saion Biotechnology Fukushima Japan

(A solution for NORM waste disposal)

Disposal of NORM:

Depending on waste classification level, chemical/physical form i.e. solid, liquid or gas, and radionuclide concentrations; a number of disposal options:

. Near surface burial
. Disposal to landfill
. Disposal to underground mines as cemented backfill
. Injection into old oil wells
. Disposal into mine waste rock dumps or power plant ash ponds
. Slurry Fraction Injection
. Dilution in industrial waste disposal facilities
. Incorporation into concrete
. Disposal into mine tailings dams

Assessment of exposure:
. External
. Suspension or re-suspension of dust particles
. Radon exhalation
. Transport by surface water (including ocean)
. Transport by ground water

Oil & Gas industry range between
10 to 10,000 Bq/kg (0.01 – 10 Bq/g) for LSA (low specific activity)
100 to 250,000 Bq/kg (0.1 – 250 Bq/g) for scales Norm

Permissible limit for discharge of Ra-226 in sea water < 1.5 Bq/L (0.005 Bq/ml)
Permissible limit for disposal of NORM in landfill 250Bq/kg (0.25 Bq/g)

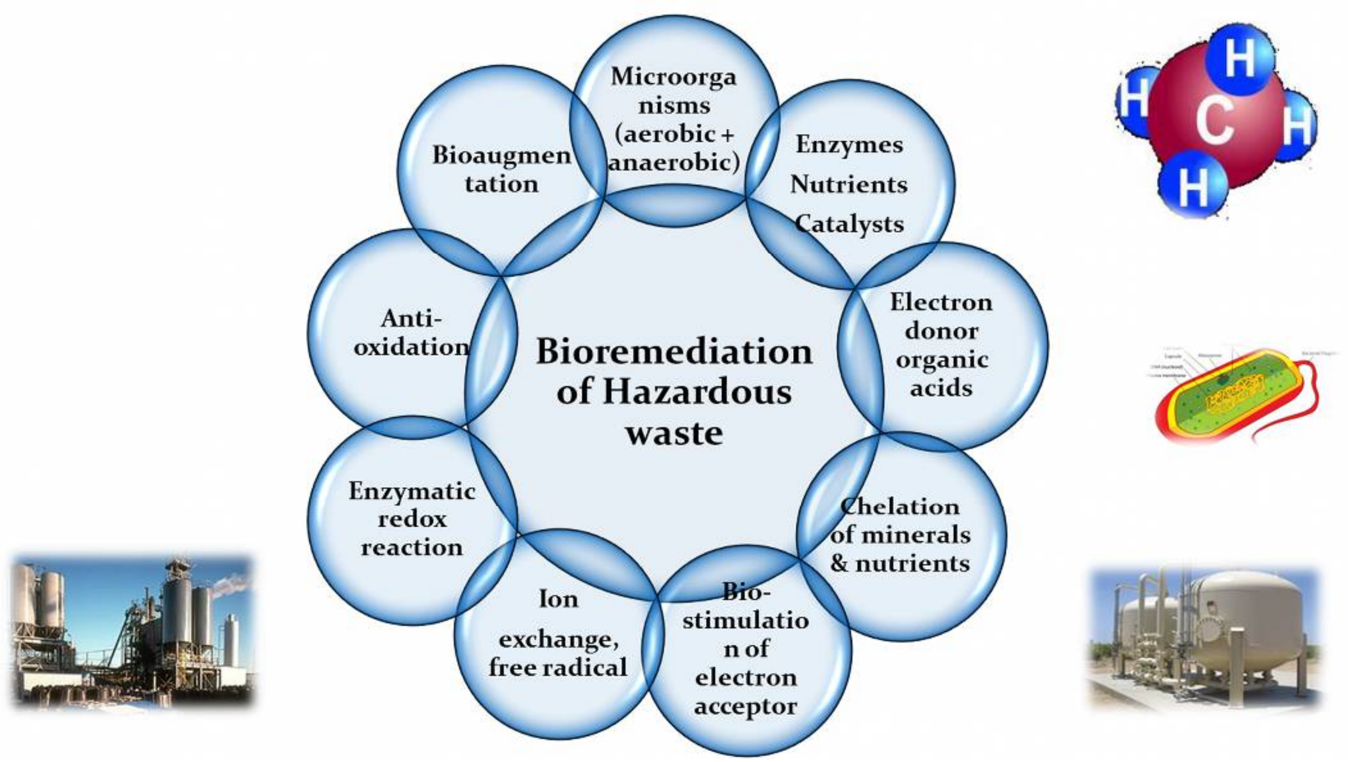
Radioactivity is disintegration of unstable nuclei and emission of ionising radiation

Mechanism:

During the bioremediation of wastes ; microorganisms synthesize and release useful substances, such as :

- organic acids (amino acids, nucleic acid, citric acids, acetic acids, lactic acids) alcohols, ethers, aldehydes
- bioactive substances (vitamins, enzymes; such as protease & lipase, hormones) sugars, polysaccharides,
- enhance the release of phosphates, fixed atmospheric N
- break down highly complex and resistant compounds (cellulose, starch, gums, lignins, carbohydrates)
- release antibiotics (streptomycin, actinomycin, neomycin)
- produce humus (fluvic acid, humic acids, humic)
- And other products (fatty acids, chelates) from the effluents and wastes.
- These microorganisms produce electron donor organic acids, enzymes and catalysts; which convert hazardous elements to non-hazardous elements. Nutrients provided during bioremediation, enhance the degradation process and act as catalyst. Enzymatic redox reaction reduces heavy metals and other contaminants as part of metabolic process both in aerobic and anaerobic conditions. Both eukaryotic and prokaryotic cells can actively transport heavy metals across their cell membrane to reduce heavy metals and other contaminants.
- In other words, microorganisms can catalyze redox reactions by a combination of several mechanisms; including enzymatic extra-cellular reduction, non-metabolic reduction by bacterial surfaces and intra-cellular reduction and precipitation.
- Similar to human metabolic system, combination of microorganism surfactants, emulsifiers, and enzymes breakdown hydrocarbons into carbon dioxide, water, fatty acids, and humic material. Microorganisms produce electron donor organic acids, enzymes, and catalysts; such as humic acid, fulvic acid, amino acids, etc. which convert hazardous elements to non-hazardous elements.
- Macronutrients provided during bioremediation of hydrocarbons; enhance the degradation process and act as catalyst. The optimum nutrient balance for hydrocarbon remediation is 100:10:4. The nutrient requirement of carbon to nitrogen is 10:1 and carbon to phosphorous is 30:1. Nitrogen makes up 15% of the molecular composition of bacteria cell, is utilized by bacteria to produce its cell walls, nucleic acid and proteins. A 4 pond of oxygen is required for a 1 pound of hydrocarbon remediation. Addition of nutrients bio-stimulates electron acceptors, whereas oxygen stimulates bioremediation. Saion formula can tolerate more than 15% of sodium.

Treatment Cycle



Conclusion

Similar to human metabolic system, combination of microorganism surfactants, emulsifiers, and enzymes breakdown hydrocarbons into carbon dioxide, water, fatty acids, and humic material. Microorganisms produce electron donor organic acids, enzymes, and catalysts; such as humic acid, fulvic acid, amino acids, etc. which convert hazardous elements to non-hazardous elements. Microorganisms deodorize VOCs; reduce COD, BOD, TOC, phenols, oils and polymers and breakdown toxic hydrocarbons. Microorganisms can catalyze redox reactions by a combination of several mechanisms; including enzymatic extra-cellular reduction, non-metabolic reduction by bacterial surfaces and intra-cellular reduction and precipitation. Both eukaryotic and prokaryotic cells can actively transport heavy metals across their cell membrane to reduce heavy metals. With the adaptation of Saion Biotechnology, following objectives can be achieved:

An effective treatment of Petroleum/Petrochemical waste, reduction in concentration of heavy metals, neutralization of toxic hydrocarbons, bioremediation of hazardous contaminants, environmentally friendly safe disposal with ISO-14000 compliance, in cost-effective manner. Biological treatments have been proven effective in reducing concentrations of nearly all the constituents of petroleum and petrochemical products typically found at contaminated sites.

Hazardous & toxic wastes can be converted into a beneficial byproduct through bioremediation process cost-effectively.

Saion Treatments are easy to adopt and can be introduced to any existing treatment system or treatment plant, to avoid an extra installation cost of equipment. A little modification can not only lead to a better and cost-effective treatment and safe disposal but also to Zero Emission.

Result oriented proven approaches; practiced in Japan can also fix the environmental problems faced by the Kingdom.

"An environmentally friendly safe disposal with ISO-14000 compliance".

SANKO

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