



# SFE News

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## FOREWORD

Early man lived in total harmony with nature. Mother nature provided them food, fuel, medicines and shelter. Fodder was added to this list as they learnt to tame animals. Once primitive man settled down and started cultivation, their instinct led them to aspire for prosperity from their lands. They must have noted during their "hunter-gatherer" days that some lands are lush green while some barely supported any vegetation. Thus, they converged in "fertile" lands on both sides of Nile, between Tigris and Euphrates or Huang Ho and Yangtze Kiang, and in the Indo-Gangetic plain. They would not have needed to search as they knew these places by heart from their own ancestral days as wandering pastorals.

Once settled down, the creative mind looked for new crops, fruits, flowers, fodders and so on. They would have noticed the range of successes and failures and almost unknowingly built up their own concept of "fertility". This pole star guided them to develop the fundamentals of agricultural practices, most importantly the inputs. With time, they also realised the necessity of replenishments. Agriculture and horticulture were, however, essentially organic and this continued till two or three centuries back.

Industrial revolution "revolutionised" human society. Urban middle class was created and man became not necessarily tagged to the land. Pressure on land, however, increased substantially to feed more mouths from the same land. We searched for more knowledge on fertility and aimed for way out. We started widespread use of chemical fertilizers, which initially came from natural mines but after Haber synthesis, came to be produced by industrial giants. With the arrival of high yielding and hybrid varieties, fertilizer use increased manyfold. No doubt we did it on compulsion and all said and done, agriculture as a whole cannot be pushed back to an entirely organic one. Our mistake was that we never really considered environment with a holistic view, vis-a-vis modern agriculture. In accord with increasing emphasis on organic inputs, we must learn to live with inorganics with a long range vision on environment conservation.



National Seminar on "Fertilizers and Environment" organised by SFE in memory of Late Prof. N. P. Datta

**Kunal Ghosh**  
President, SFE

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# LEAD NEWS: Eutrophication, hypoxia, dead zones and nutrient cycle-threat to coastal ecosystem

The urban developments are taking up fertile agricultural land leading to pollution of rivers, estuaries and seas by sewage as well as industrial and agricultural effluents. In turn, this is posing a threat to coastal ecosystems, their biological diversity, environmental regulatory functions and role in generating employment and food. Overuse of fertilizer can result in eutrophication, and in extreme cases, the creation of 'dead zones'. Dead zones occur when excess nutrients—usually nitrogen and phosphorus—from agriculture or the burning of fossil fuels seep into the water system and fertilize blooms of algae along the coast. As the microscopic plants die and sink to the ocean floor, they feed on bacteria, which consume dissolved oxygen from surrounding waters. This limits oxygen availability for bottom-dwelling organisms and the fish that eat them. In dead zones, huge growths of algae reduce oxygen in the water to levels so low that nothing can live. There are now more than 400 known dead zones in coastal waters worldwide, compared to 305 in the 1990s, according to a study undertaken by the Virginia Institute of Marine Science. Those numbers were up from 162 in the 1980s, 87 in the 1970s, and 49 in the 1960s. In the 1910s, four dead zones had been identified (Minard, 2008). The occurrence of hypoxia in shallow coastal and estuarine areas has been increasing worldwide, most likely accelerated by anthropogenic activities. Hypoxia in the Northern Gulf of Mexico, commonly named the 'Gulf Dead Zone', has doubled in size since researchers first mapped it in 1985, leading to very large depletions of marine life in the affected regions (Portier, 2003). He studied changes in microbial communities as a result of oxygen depletion, the potential contribution of increasing hypoxia to marine production and emission of N<sub>2</sub>O and CH<sub>4</sub>, and the effect of hypoxic development on methyl mercury formation in bottom sediments at the Gulf of Mexico's Texas-Louisiana Shelf during the summer months. The World Resources Institute reported that driven by a massive increase in the use of fertilizer, the burning of fossil fuels, and a surge in land clearing and deforestation, the amount of nitrogen available for uptake at any given time has more than doubled since the 1940s. In other words, human activities now contribute more to the global supply of fixed nitrogen each year than natural processes do, with human-generated nitrogen totaling about 210 million metric tons per year, while natural processes contribute about 140 million metric tons (Table 1).

This influx of extra nitrogen has caused serious distortions of the natural nutrient cycle, especially where intensive agriculture and high fossil fuel use coincide. In some parts of northern Europe, for example, forests are receiving 10 times the natural levels of nitrogen from airborne deposition, while coastal rivers in the Northeastern United States and Northern Europe are receiving as much as 20 times the natural amount from both agricultural and airborne sources. Recently, a new class of chemical substances with toxic and persistent properties was detected in the environment - the polyfluorinated compounds (PFCs). At the Institute for Coastal Research scientific studies were performed on the PFC-contamination of coastal waters, marine mammals and the atmosphere with emphasis on the mechanisms of global transport and distribution of PFCs (Coastal Wiki, 2008).

**Literatures cited**

1. Coastal Wiki (2008). Polyfluorinated compounds - a new class of global pollutants in the coastal environment (<http://www.Polyfluorinated compounds PFC - pollutants in coialstal water.htm>).
2. Minard Anne (2008). Dead zones multiplying fast, coastal water study says (<http://www.Dead Zones Multiplying Fast.htm>)
3. Portier Ralph, J. (2003). Trends in Soil Science, Technology and Legislation in the USA. *Journal of Soils and Sediments* 3(4):257.
4. World Resources Institute (2006). Environment information portal (<http://www.Nutrient Overload Unbalancing the Global Nitrogen Cycle.htm>).

**Table 1. Global sources of Biologically Available (Fixed) Nitrogen (Source: World Resources Institute, 2006)**

Sources	Annual release of fixed nitrogen (teragram)
<b>Anthropogenic/human</b>	
Fertilizer	80
Legumes and other plants	40
Fossil fuels	20
Biomass burning	40
Wetland draining	10
Land clearing	20
<b>Total from human sources</b>	<b>210</b>
<b>Total from natural sources (viz., Soil bacteria, algae, lightning etc.)</b>	
	<b>140</b>

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## Fertilizers and Environment: Issues of Concern

### Impacts on the fishery in the La Plata river system in South America

Fruit and seed eater species of the genera *Colossoma* and *Brycon* and the big catfish *Paulicea lutkenii* have practically disappeared from the commercial catch in the lower Paraná river, and also from the catches in the La Plata and Uruguay rivers.

- Fish species of marine lineage of the genera *Basilichthys* and *Lycengraulis*, usually moving upstream from the estuary in winter, have practically disappeared from the commercial catches in the middle Paraná.
- The commercial catches of the pelagic top predator *Salminus maxillosus* have been decreasing since the late 1940s in all the lower basin, though its commercial catch has been highly restricted.
- Populations of most of the migratory fish species are severely diminished in the middle and upper Uruguay river.
- Relatively high levels of agricultural pesticides and heavy metals were detected in fish tissues.
- Periodic massive fish mortalities were reported in the lower Paraná delta and the La Plata river.
- Low water oxygen levels and massive fish mortalities were detected in the lower Paraguay river, and discharges of high organic matter content effluents from the agricultural industry have increased in the upper basin.
- The exotic *Cyprinus carpio* was the most important species in biomass in the experimental catches in the La Plata river, and its catch has been increasing in the middle Paraná.
- Maximum size of catch of the big catfish of the genera *Pseudoplatystoma* has been decreasing for the last three decades in the lower middle Paraná.
- The conflicting situations between recreational and commercial fishermen have been increasing, and the trophy size of *Salminus* has been decreasing at the confluence of the Paraná and Paraguay rivers, though total fishing effort seems not to have increased.

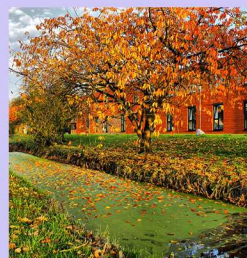
### Eutrophication:

- Fertilization of surface waters (eutrophication) results in, for example, explosive growth of algae which causes disruptive changes to the biological equilibrium [including fish kills]. This is true both for inland waters (ditches, river, lakes) and coastal waters.
- Groundwater is being polluted mainly by nitrates. In all countries groundwater is an important source of drinking water. In several areas the groundwater is polluted to an extent that it is no longer fit to be used as drinking water according to present standards.

While these problems were primarily attributed to mineral fertilizers by FAO/ECE, in some areas the problem is particularly associated with extensive and intensive application of organic fertilizers (manure).

### Food and Agricultural Organisation

[[http://www.fao.org/docrep/w2598E/w2598e06.htm#management of water quality impacts from fertilizers](http://www.fao.org/docrep/w2598E/w2598e06.htm#management%20of%20water%20quality%20impacts%20from%20fertilizers)]



## Eco-friendly retting of jute - The future ahead

Jute is an environment friendly crop producing vegetable fibres for a number of commercial uses. Retting of jute (*Corchorus spp.*) is the most important biochemical process for the production of 'golden fibre'. Under conventional retting slow moving soft water is essentially required for quality fibre production; in absence of that farmers ret their jute repeatedly in the same stagnant water of natural tank, road side ditches, etc. culminating in poor quality fibre generally not suitable for high valued diversified products (Pic. 1). Further, quick conversion of aerobic to complete anaerobic condition under conventional retting facilitates the growth of several pathogenic microbes, water borne insects, etc., resulting in unhealthy environmental condition.

Under this situation, the talc based microbial formulation 'CRIJAF SONA' developed by CRIJAF consisting of three different strains of *Bacillus pumilus* proved to be effective for jute and mesta (*Hibiscus spp.*) retting in stagnant but limited amount of water under varied agro-climatic situations in different states of India. These strains of *Bacillus pumilus* are very good pectin and xylan degraders without any cellulolytic activity, spore forming but non-pathogenic. In water scarce situation retting can be carried out in natural retting tank, polythene lined or concrete tank in shorter duration by using this microbial formulation for each layer of *jak* during the process of retting. Thirty kg of formulation is needed for retting of jute plants from 1 ha costing Rs. 900 only. Besides reduction in retting duration by 6 to 7 days, the quality of fibre is also improved by at least 1 to 2 grade (Pic. 2), and farmers can earn an additional income of Rs. 6000 to 9000 per ha over conventional method of retting (Table 2) confirmed from trials conducted in farmers' fields. The environmental condition causing skin related problems and fowl odour under conventional method is also substantially improved.

In conclusion, there is still scope for further improvement of the technology if the retting through microbial formulation is done on fibre strips by extracting the same following mechanical means instead of doing on whole plants described above.

**Table 2. Effect of microbial formulation on retting duration and fibre strength of jute**

District & State	No. of demonstrations	Retting duration (days)		Enhanced fibre strength (g/tex) with microbial formulation
		With microbial formulation	Without microbial formulation	
Hooghly, West Bengal	44	9-14 (11.6)*	15-19 (18.2)	23.1-30.1 (26.2)
North 24 PGS, West Bengal	79	10-17 (13.4)	17-21 (19.5)	23.9-28.8 (25.2)
Nadia, West Bengal	57	11-19 (14.6)	21-23 (22)	23.3-31.6 (25.7)
Murshidabad, West Bengal	05	13-14 (13.6)	16-21 (18.6)	24.0-29.0 (25.4)
Malda, West Bengal	20	12-14 (12.7)	17-22 (19.5)	23.5-26.1 (24.6)
Baharaich, Uttar Pradesh	15	09-11(9.2)	15-17 (16.3)	23.5- 30.8 (25.8)
Srikakulam, Andhra Pradesh	60	13-15 (13.6)	22-25 (23.8)	-

\*Data in parenthesis indicate the mean value



Pic. 1. Conventional method of retting and resultant black coloured fibre



Pic. 2. Improved retting with microbial formulation and the resultant golden fibre

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### Snippet

#### Sinochem developed fertilizer technologies

During the 11th Five-year Plan, in terms of R&D of new technologies, Sinochem developed several domestically leading technologies, including the

- refined wet phosphate acid technique
- low-temperature thermal recovery technique in the production of sulfuric acid
- deep hydrolyzing technique of waste urea liquid, & high-tower compound fertilizer dehumidifying technique.

[<http://english.sinochem.com/g762.aspx>]

## Sisal to save environment

Sisal (*Agave sisalana*), a leaf fibre yielding plant, is well adapted to arid environments and suited in the changing climatic situation characterised by elevated mean temperature, erratic and insufficient rainfall over the central plateau region of India. It is a perennial crop and requires less agro-activities for its sustenance. The blue water footprint of sisal is only  $9 \text{ m}^3 \text{ t}^{-1}$  of fibre produced, much lower than other vegetable fibres like jute ( $33 \text{ m}^3 \text{ t}^{-1}$ ) and ramie ( $201 \text{ m}^3 \text{ t}^{-1}$ ). Recommended double row planting of sisal checks soil erosion, restricts runoff loss of rain water, improves absorption of rain water in the soil layer. Fortunately sisal is not much infested by many disease and insect pests; and therefore, sisal plantation does not produce pesticide load to the environment. Besides, sisal plants reduce soil erosion through its extensive root system and contributes positively to watershed management (FAO, 2014). The waste of sisal contains 0.6% N, 0.1% P, 0.08% K, 2.46% Ca and 0.16% Mg; and its use @  $10 \text{ t ha}^{-1}$  can increase exchangeable Ca level from 10 to 99  $\text{mmol Ca kg}^{-1}$ , although report to the contrary of soil fertility decline in Ferralsols under hybrid sisal cultivation in Tanzania has also been documented (Hartemink, 1995). The positive effect of sisal waste on soil properties was however demonstrated (Osborne, 1967)

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1. Hartemink Alfred E. (1995). Soil fertility decline under sisal cultivation in Tanzania, Technical Paper No. 28, International Soil Reference and Information Centre in Wageningen, The Netherlands.
2. Osborne, J.F. (1967). Some preliminary estimates of nutrient removal by agave crops, Tanganyika Sisal Growers' Association, Tanzania
3. FAO (2014). Sisal. In: [www.fao.org/economic/futurefibres/fibres/sisal/en/](http://www.fao.org/economic/futurefibres/fibres/sisal/en/)



Pic. 3. Vast fallow land mass in the central plateau region of India turned green by sisal plantation



Pic. 4. Sisal waste is a promising source of organic manure to arrest carbon depletion in the drier tracts of India

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## Fertilizer application – Innovation technology

Nutrient Expert® offers a 'nutrient smart' approach to fertilizer use, by increasing efficiency and reducing emissions

A fertilizer decision-support tool, Nutrient Expert® for South Asia, launched in India last July, has been selected as the 'best innovation' in the Information and Communications Technology Solutions category at the Bihar Innovation Forum II, according to a press release from the International Plant Nutrition Institute (IPNI). The toolkit has been developed by IPNI in collaboration with International Maize and Wheat Improvement Center (CIMMYT) and validated in close collaboration with National Agricultural Research and Extension Systems (Indian Council of Agriculture Research, Agriculture Universities, Departments of Agriculture), private sector (seed and fertilizer industry representatives) and farmer organisations.

The tool is being used as part of a 'nutrient smart' approach to fertilizer use in CCAFS project of Climate Smart Villages in India to increase efficiency in nutrient use and reduce emissions.

Nearly 90 percent of small-holder farmers do not have access to soil testing facilities and the tool can provide location-specific fertilizer recommendation to individual farmers.

The Bihar Innovation Forum is a one-of-a-kind platform that aims to identify, celebrate and scale-up innovations for the betterment of rural livelihoods in the State.

[<http://ccafs.cgiar.org/blog/fertilizer-tool-used-climate-smart-villages-wins-%E2%80%98best-innovation-technology%E2%80%99-title#.VIRHxtKUeSM>]



## Organic jute is not a distant dream

The demand for organic jute is increasing day-by-day in the developed countries, especially as a packaging material for organically grown food grains. Besides, there is great demand for diversified products made of organic jute in the European countries. Following are the technologies recommended for organic jute cultivation based on a series of trials in research farm as well as in farmers' fields.

Land preparation, seed rate, spacing, irrigation scheduling and harvesting are same as those of the inorganic jute cultivation. Any variety of choice can be grown for organic jute cultivation. The ruling high yielding varieties like JRO 524, JRO 128, JRO 204 and JRO 8432 were found promising under organic jute cultivation in the trials conducted. It is recommended to use certified seeds being sold by Government agencies or by reputed firms to ensure better germination and prevent the seed-borne diseases to a considerable extent. In addition, treating the seeds with antagonistic fungus *Trichoderma viride* is suggested for organic jute cultivation. For organic jute cultivation, organic manure in the form of well-decomposed FYM needs to be applied during final soil preparation. Alternatively, growing sunnhemp as a pre-kharif green manure crop and incorporating the same in the soil at 45 DAS was observed to add 25-30 kg N ha<sup>-1</sup>. Besides, the biofertilizers like *Azotobacter* should also be applied after thinning the excess population at 15-21 DAS. It is recommended to go for either two hand weedings, or adopt mechanical means employing wheel hoe during 15 and 21 DAS. The traditional whole plant retting may be hastened by applying the retting consortia developed by CRIJAF. By adopting the organic jute cultivation technology, it was possible to harvest fibre yield up to 16 q ha<sup>-1</sup> of fibre. The technologies have been demonstrated on large-scale basis in near about 100 ha area with the involvement of as many as 725 small and marginal framers in North-24-Parganas of West Bengal, and the full package recommended is shown in Table 3.

**Table 3. Package of practices for organic jute cultivation**

Varieties	:	No specific variety for organic jute and any ruling variety of choice may be grown organically.
Seed rate	:	3-4 kg for seed drill; 5-6.5 kg for broadcasting
Seed treatment	:	<i>Trichoderma viride</i> @ 10 g kg <sup>-1</sup> of seed
Spacing	:	25 × 5-7 cm
No. of irrigations	:	One pre-sowing irrigation + 2-3 additional irrigations at hairline-crack stage
Manuring	:	Pre-kharif green manuring of sunnhemp (preferable)+organic manure (either compost or FYM to supply 25-30 kg N ha <sup>-1</sup> )+ <i>Azotobacter</i> culture @ 5 kg ha <sup>-1</sup> at 3 weeks after sowing (i.e. after weeding-cum-thinning)
Weeding	:	Two hand weedings, one at 21 DAS and the second one at 35 DAS. Alternatively, mechanical weeding by wheel hoe twice at 15 and 21 DAS. Red amaranthus @ 20 kg ha <sup>-1</sup> is also recommended
Pest management	:	Neem oil @ 2-3 mL L <sup>-1</sup> of water
Harvesting	:	120 DAS
Post-harvest operation	:	Ribbon retting or conventional whole plant retting with microbial consortia
Organic certification	:	Organic certification requires scheduled field visits and observations by the people from an accredited certification body, for which the charges levied by the certification body need to be borne by the farmer.



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### Inspiration Green comments

"Fertilizers do not just affect the crops on which they are applied, but drain off into the soil and nearby waterways. In aquatic systems, they boost the growth of algae, which bloom en masse and deprive the surrounding water of oxygen. This process is called eutrophication, and areas of severe eutrophication – waters that do not have enough oxygen to support life – are known as dead zones. The leaching nitrates can also impact drinking water supplies if located near wells, and nitrate-contaminated water has been linked to gastric problems in adults. Infants are more susceptible to adverse health effects, and should not consume water with concentrations of nitrate in excess of 10 mg L<sup>-1</sup>. Since most purification methods do not effectively remove nitrates from water, contamination ought to be prevented in the first place."

[<http://www.inspirationgreen.com/chemical-fertilizers.html>]

## Fertilizers and Environment: Issues of Concern

“Observed as to how human activity has changed the natural cycling of nitrogen to create a friend-turned-foe dilemma, and called for greater public awareness of nitrogen pollution and concerted global action to control it. It’s been said that nitrogen pollution is the biggest environmental disaster that nobody has heard of. People can see an oil slick on the ocean, but hundreds of tons of nitrogen spill invisibly into the soil, water and air everyday from farms, smokestacks and automobile tailpipes. But the impact is there — unhealthy air, unsafe drinking water, dead zones in the ocean, degraded ecosystems and implications for climate change. But people don’t see the nitrogen spilling out, so it is difficult to connect the problems to their source. It has been noted that nitrogen inputs to the terrestrial environment have doubled worldwide during the past century. This increase is due largely to the invention and widespread use of synthetic fertilizer, which has revolutionized agriculture and boosted the food supply.”

**Alan Townsend**

[<http://www.acs.org/content/acs/en/pressroom/newsreleases/2011/august/friend-and-foe-nitrogen-pollutions-little-known-environmental-and-human-health-threats.html>]

Increased fertilizer use over the past 50 years is responsible for a dramatic rise in atmospheric nitrous oxide, which is a major greenhouse gas contributing to global climate change. It is attributed to the application of nitrogen-based fertilizer, which stimulates microbes in the soil to convert nitrogen to nitrous oxide at a faster rate than normal. Since the year 1750, nitrous oxide levels have risen 20 percent – from below 270 parts per billion (ppb) to more than 320 ppb. After carbon dioxide and methane, nitrous oxide (N<sub>2</sub>O) is the most potent greenhouse gas, trapping heat and contributing to global warming. It also destroys stratospheric ozone, which protects the planet from harmful ultraviolet rays. It is further suggested to bring about changes in fertilizer use and agricultural practices that will help to mitigate the release of nitrous oxide into the atmosphere.

**University of Berkeley, California, USA**

[<http://newscenter.berkeley.edu/2012/04/02/fertilizer-use-responsible-for-increase-in-nitrous-oxide-in-atmosphere/>]

Sulfuric acid is essential to phosphoric acid production. The phosphatic fertilizer plants also produce their own sulphuric acid. The acid is mixed with finely ground phosphate rock producing noxious vapors containing heavy metals, sulfates, fluorosilicates, hydrogen fluoride and other contaminants. Uncontrolled releases of highly toxic hydrogen sulfide gas are commonplace, especially during unloading in the molten state. Spills from toxic waste-water ponds dump hundreds of millions of gallons of highly acidic water laced with toxic fluorides, radionuclides, heavy metals, sulfites and phosphoric acid into rivers and streams. Massive fish kills are not unusual when these spills occur. There are few regulations governing wastes from phosphoric acid and superphosphate fertilizer production in USA and elsewhere. The insidious problem with airborne fluorides is that they can be very reactive when they come in contact with moisture. When inhaled, many fluoride salts react with water (moist lung tissue) and break down into hydrofluoric acid and a toxic component. The reaction of hydrofluoric acid with lung surface burns a tiny hole in the tissue, and the toxic component is left at the site of damage. People living near phosphate fertilizer plants are twice as likely to develop lung cancer and osteoblastic leukemia. Workers in these factories, it has been reported, have to go into acid reaction chambers filled with toxic fumes and scour scale from filters and walls. The scale is radioactive up to 100,000 picocuries of radium per gram. The radioactive wastes are either buried in the gypsum stacks or dumped into holding ponds. Only recently has the Florida Department of Environmental Protection (FDEP) required companies to place liners under phospho-gypsum stacks.

**George Glasser**

[<http://www.greens.org/s-r/29/29-18.html>]

**Views**

Healthy soils equal healthy crops and therefore healthy people. Smallholder farmers feed an ever-growing population. Helping them increase food production and incomes, while improving the resilience of their production systems and mitigating environmental problems, is the cornerstone of IFDC

**Amit Roy, President & CEO, IFDC, USA**

Agricultural interventions, particularly those entailing substitution of biological processes with fossil fuel-derived energy or inputs, lead to a highly interactive pattern of interactions within four major soil functions-carbon transformations, nutrient cycles, soil structure maintenance, and regulation of pests and diseases. Although organic carbon is the common currency of the soil system and its transfer with associated energy flows is the main factor that integrates the major soil functions, nutrient additions and cycling play a vital role in the maintenance of soil health. It is a myth that synthetic nitrogen undermines soil health by destroying soil organic carbon.

**Bijay Singh, INSA Senior Scientist, PAU, India**

**News**

Society for Fertilizers and Environment, Kolkata and Raman Centre for Applied and Interdisciplinary Sciences, Kolkata in collaboration with ICAR, New Delhi, FICCI, New Delhi and other bodies, will organize a One day National Conference on "Indigenous innovation and transfer of foreign technology in fertilizer industry : Needs, constraints and desired simplification" at ICAR-CRIJAF, Nilgunj, Kolkata-700120, West Bengal on 17 January 2015 to deliberate on the major changes necessary to "make (fertilizer) in India" with "zero defect and zero effect".

IFA commemorates the celebration of the World Soil Day and International Year of Soils in 2015

CIEC held the 16th World fertilizer Congress -Technological Innovation for a sustainable Tropical Agriculture, Rio de Janeiro, Brazil, 20-24 October 2014 [<http://www.16wfc.com/presentation>]

The Brazilian Agricultural research Enterprise (Embrapa), under the auspices of FertBrasil Network, Esalq/USP and the International Scientific Center of Fertilizers (CIEC) hosted the World Fertilizer Congress for getting together the most recent topics of discussion regarding the fertilizer sector in Brazil and all over the world.

The theme of the Congress focused on

- Controlled release fertilizers
- Micronutrients and secondary macronutrients in NPK fertilizers
- Fertilizers and environmental impacts
- New routes for fertilizer production
- Organic based fertilizers and biofertilizers
- Direct use of agrominerals

*Healthy soils lead to healthy life*

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