Effect of fertilizers and pesticides use on environment and health

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- Agrochemicals (chemical fertilizers and pesticides) have made a phenomenal contribution worldwide towards the production and preservation of food, fiber and cash crops.

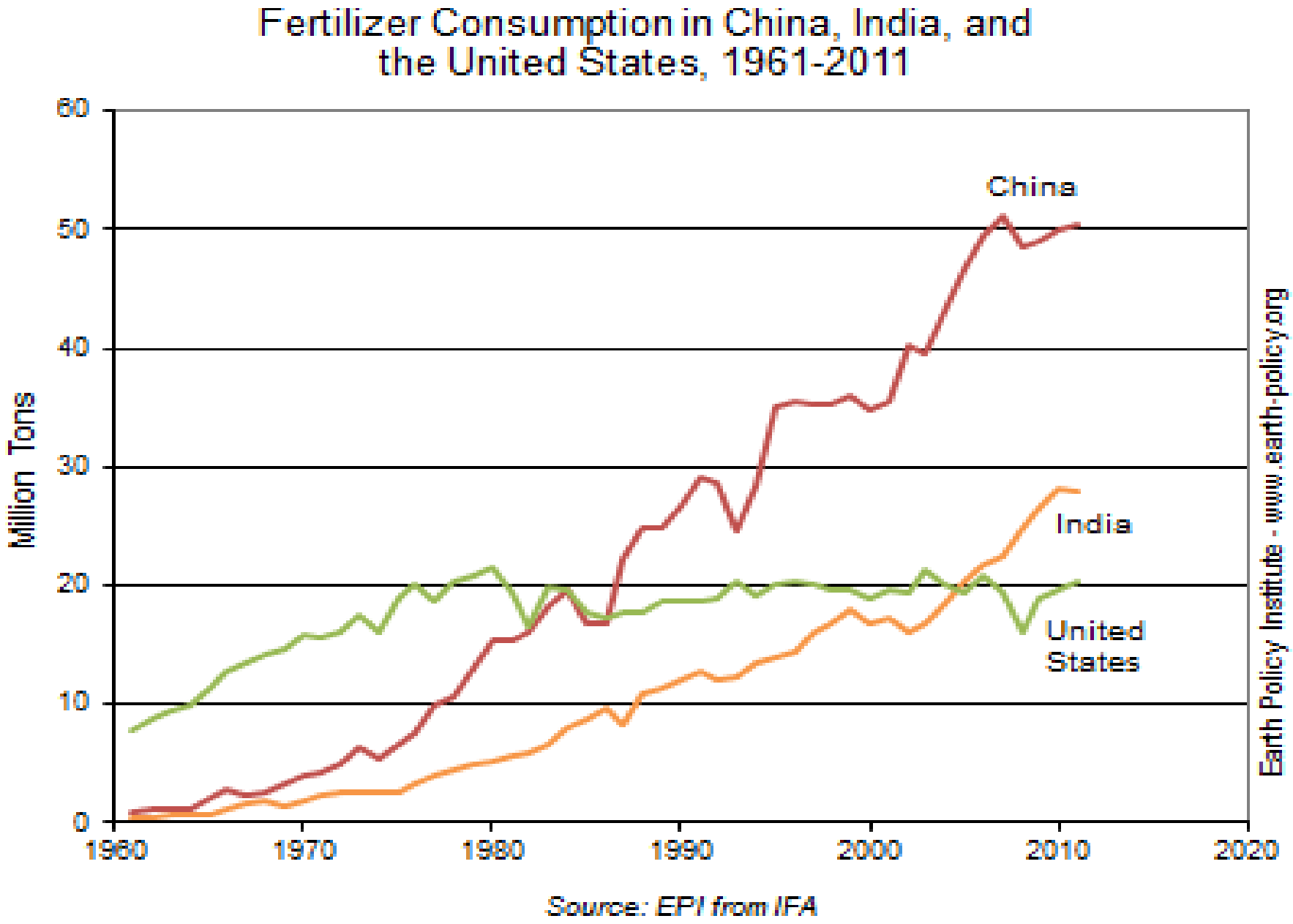
- In India, the increased use of fertilizers and pesticides in agriculture started since 1970s as part of the Green Revolution to meet the nutrients demand of high yielding and fertilizer responsive varieties of rice and wheat.

Just to keep up with food demand, we need record global crop production every year.

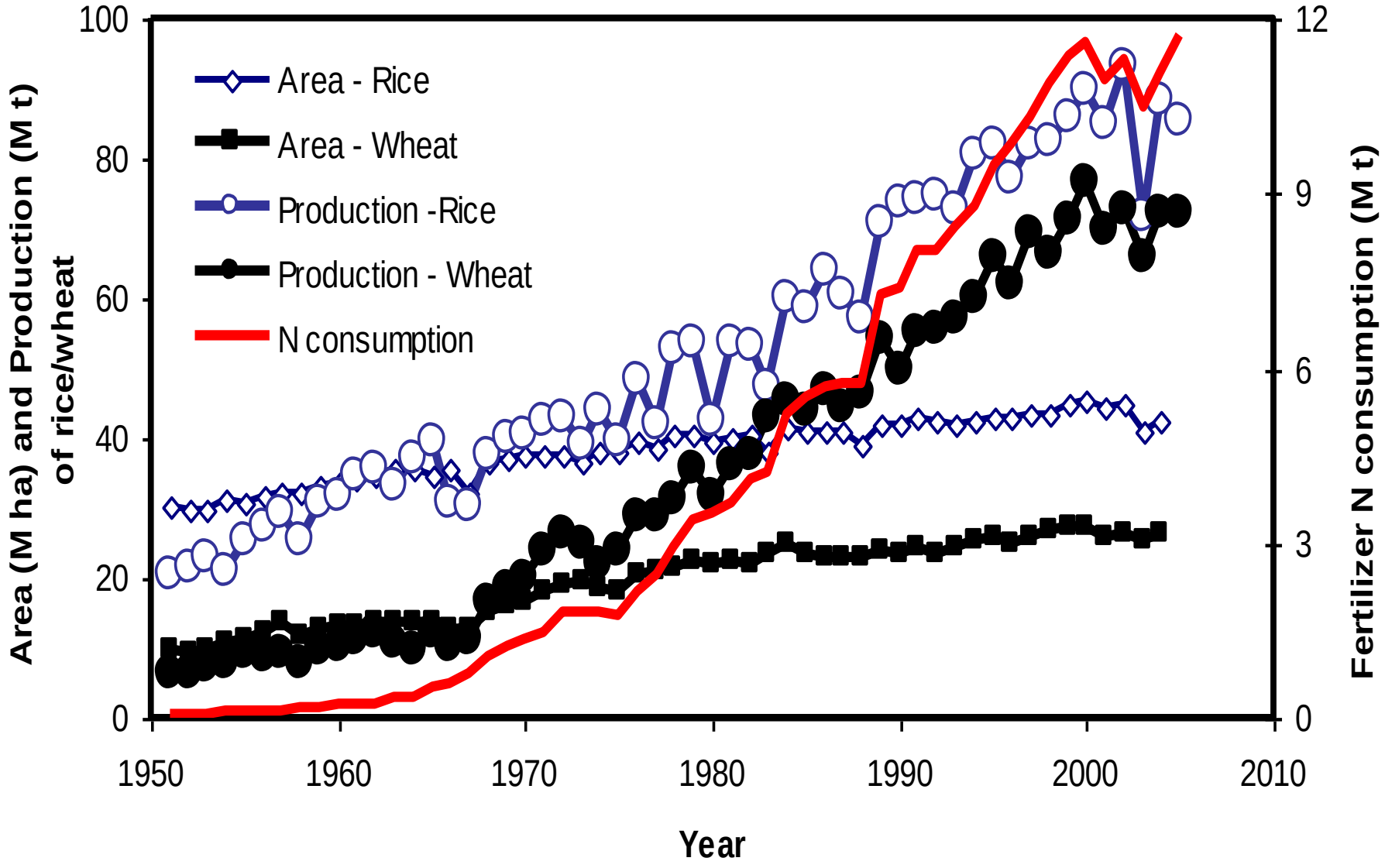
"This is a basic problem, to feed 6.6 billion people. Without chemical fertilizer, forget it. The game is over."

Dr. Norman Borlaug
Nobel Peace Prize Winner

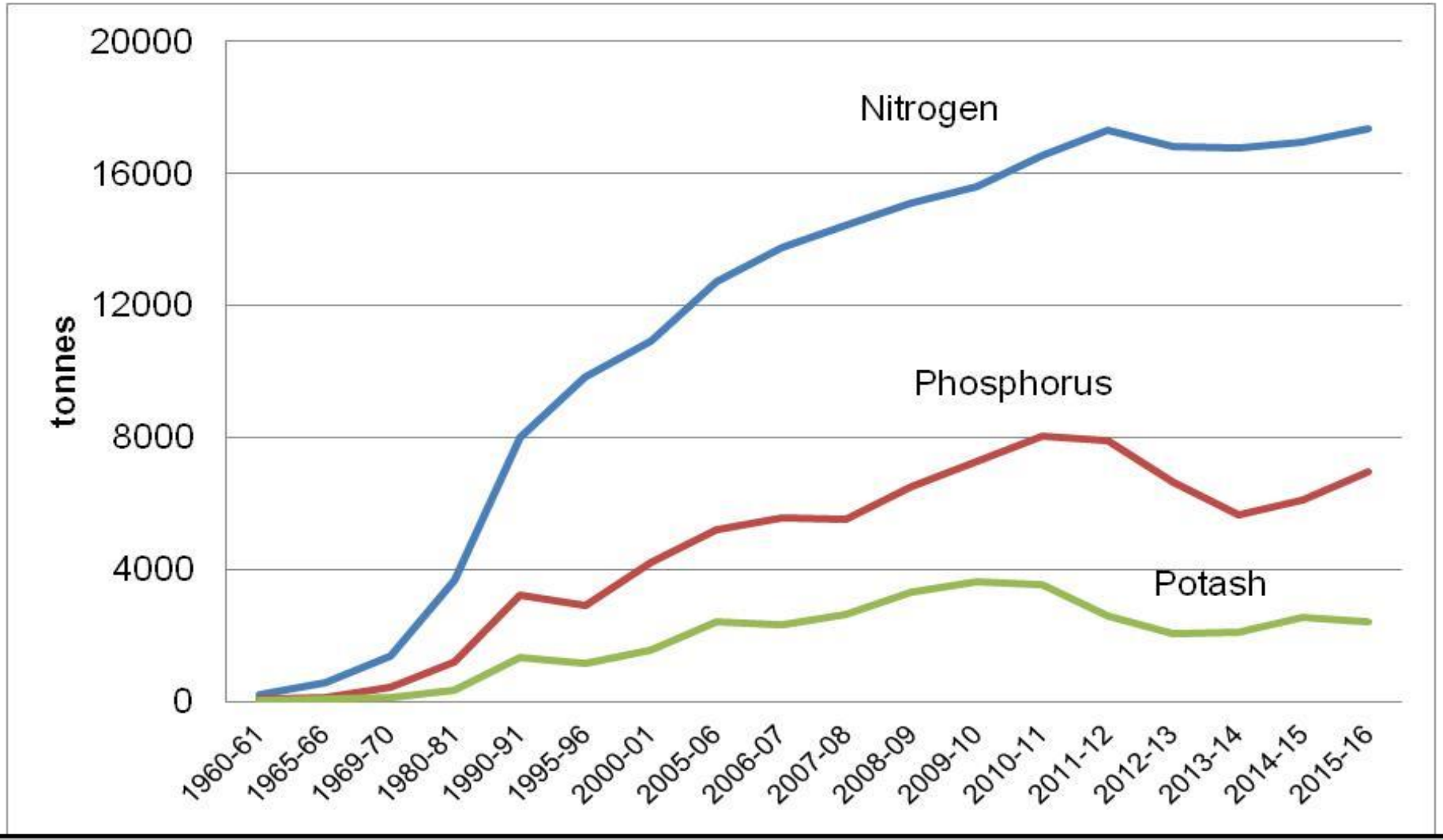
Fertilizer is a Strategic Commodity


Fertilizer Consumption in China, India, and the United States, 1961-2011
Million Tons
60
50
40
30
20
10
0
1960
1970
1980
1990
2000
2010
2020
China
India
United States
Earth Policy Institute - www.earth-policy.org
Source: EPI from IFA

Fertilizer use and food production in India



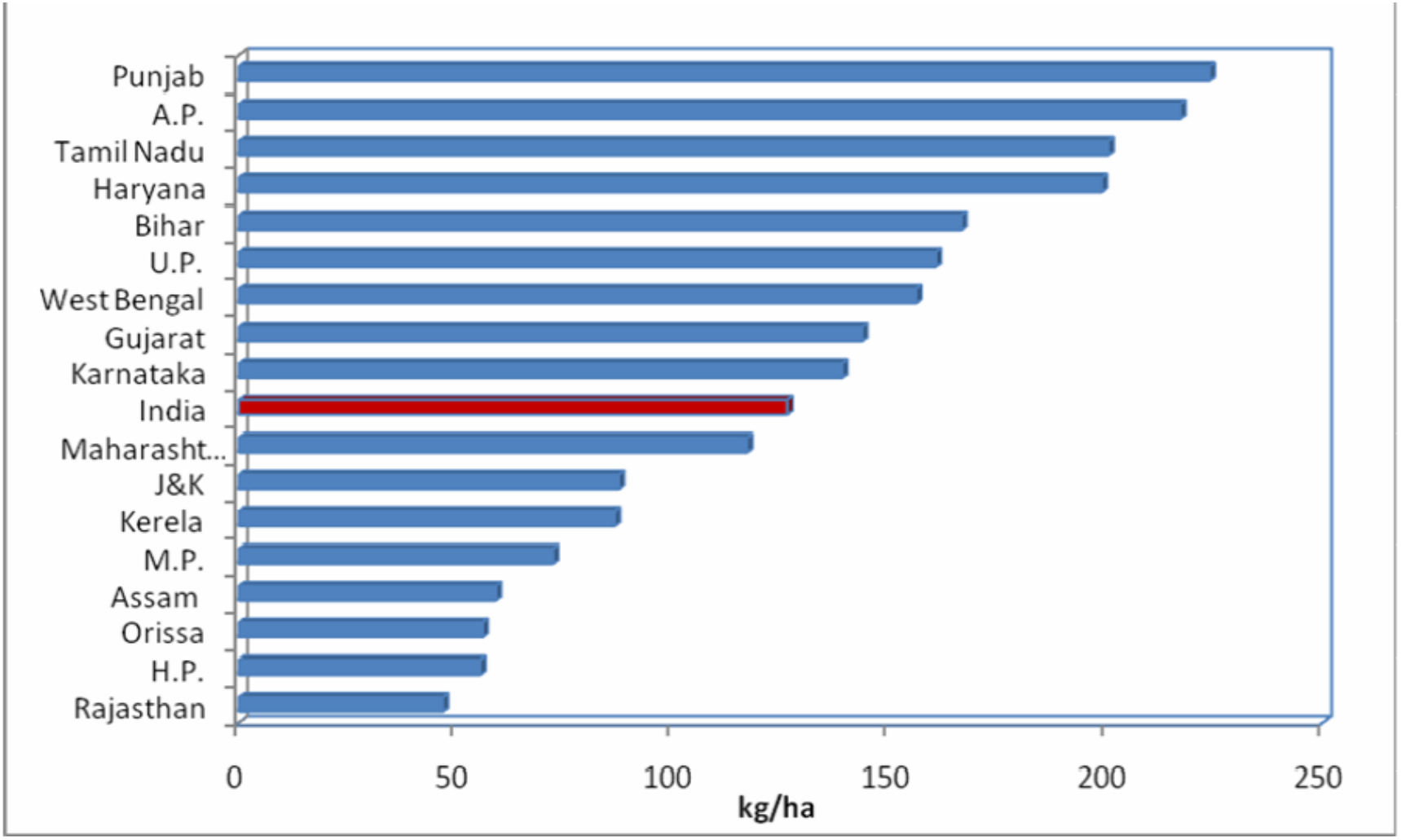
Trends in fertiliser consumption (N, P and K) in India



It is only with the use of mineral fertilizers that the continuously growing Indian population can be fed.

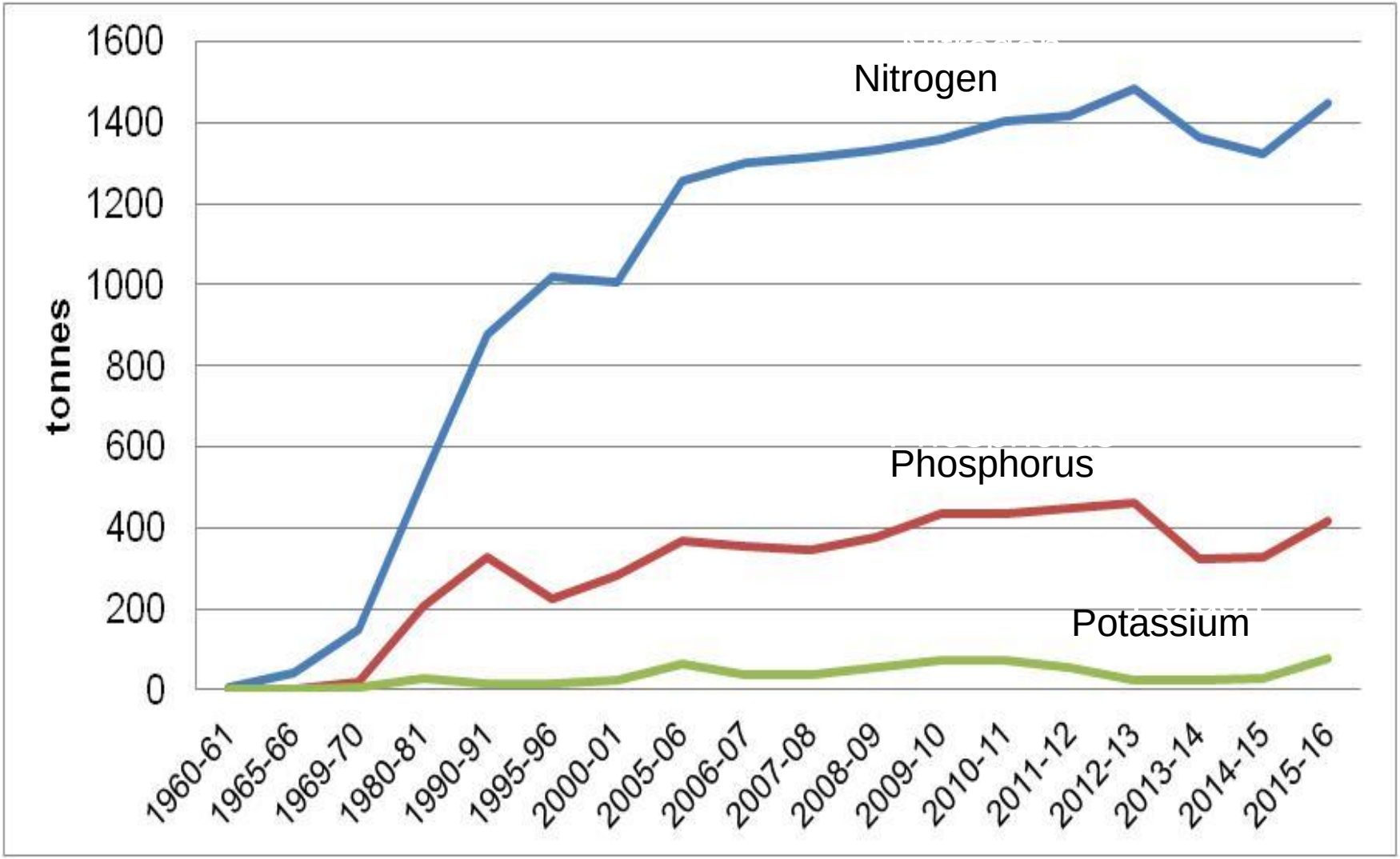
Per hectare fertiliser use by states in India

(kg/ha)



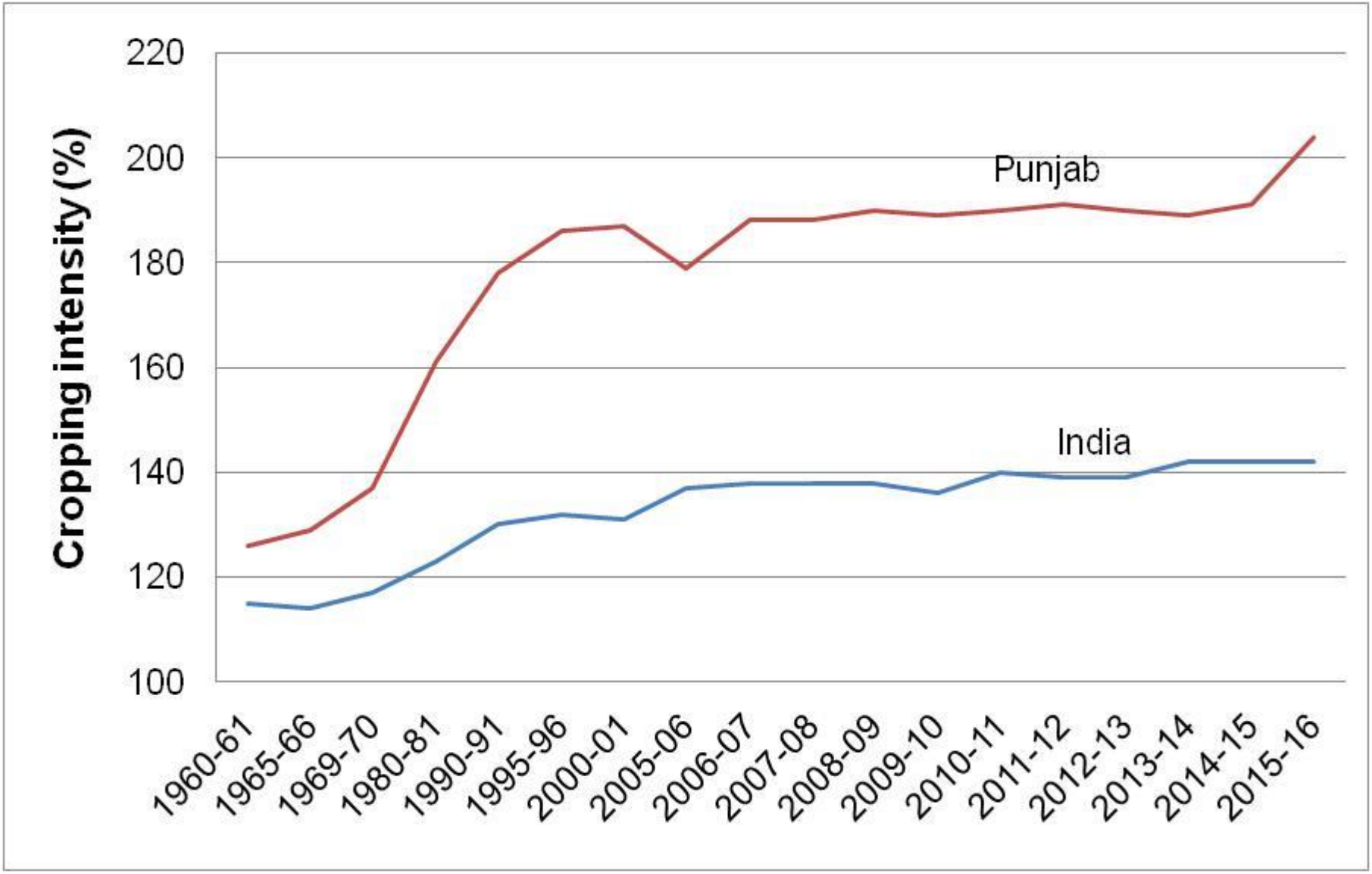
Source : Fertilizer Association of India (2010)

Trends in fertiliser consumption (N, P and K) in Punjab

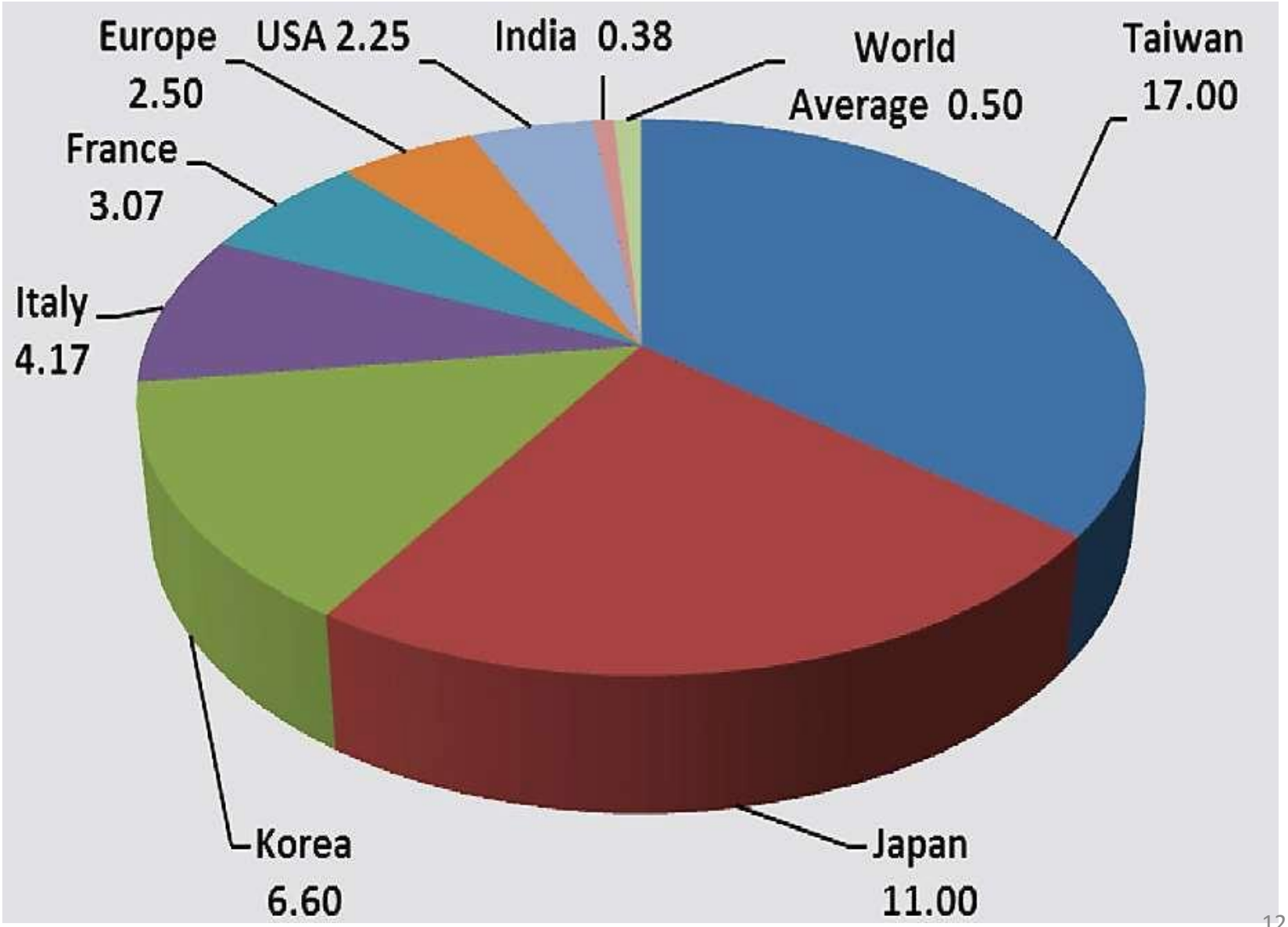


Source: Fertiliser Association of India)

Cropping intensity in India and Punjab



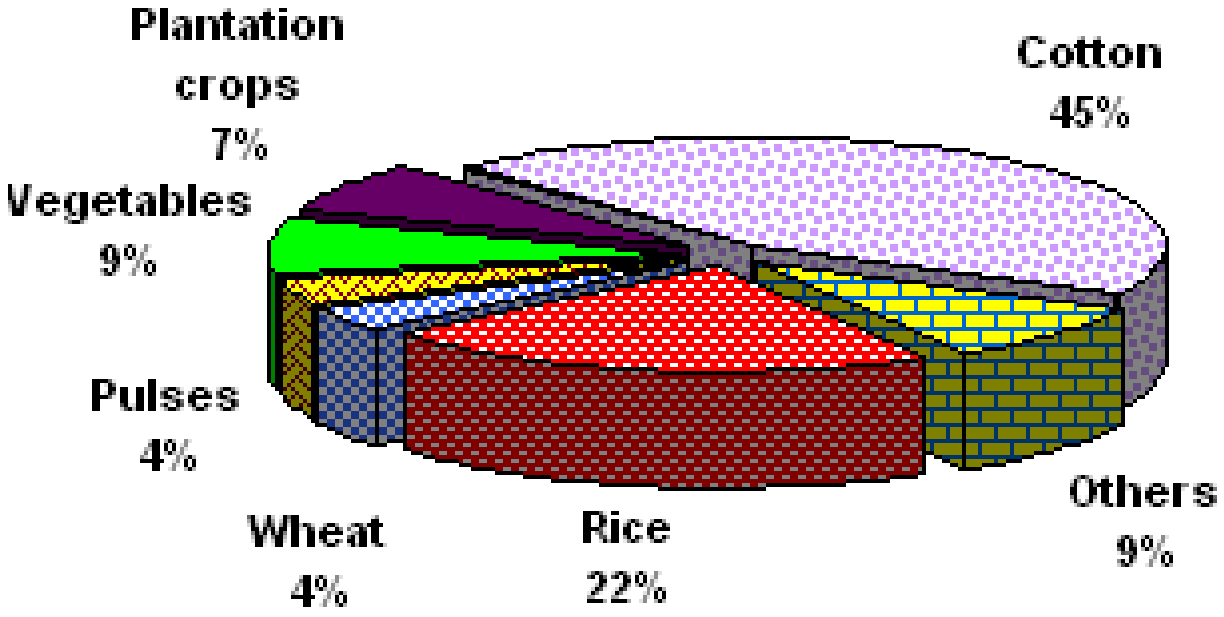
Pesticide consumption (kg/ha) in different countries



Pesticide consumption by different crops in India

Among all the crops grown in India, pesticide consumption in cotton is highest (45 %) followed by paddy (22 %), vegetables (9 %), Plantation crops (7 %), wheat (4 %), pulses (4 %) and others (9 %).

Among the vegetable crops in India, cabbage is the maximum pesticide consuming crop.



The other side: Environment and health

Effects on SOIL

Fertilizers if applied in excess can cause great harm to soil. These can lead to :-

- Effect on soil fertility through nutrient imbalance
- Soil pH
- Soil salinity

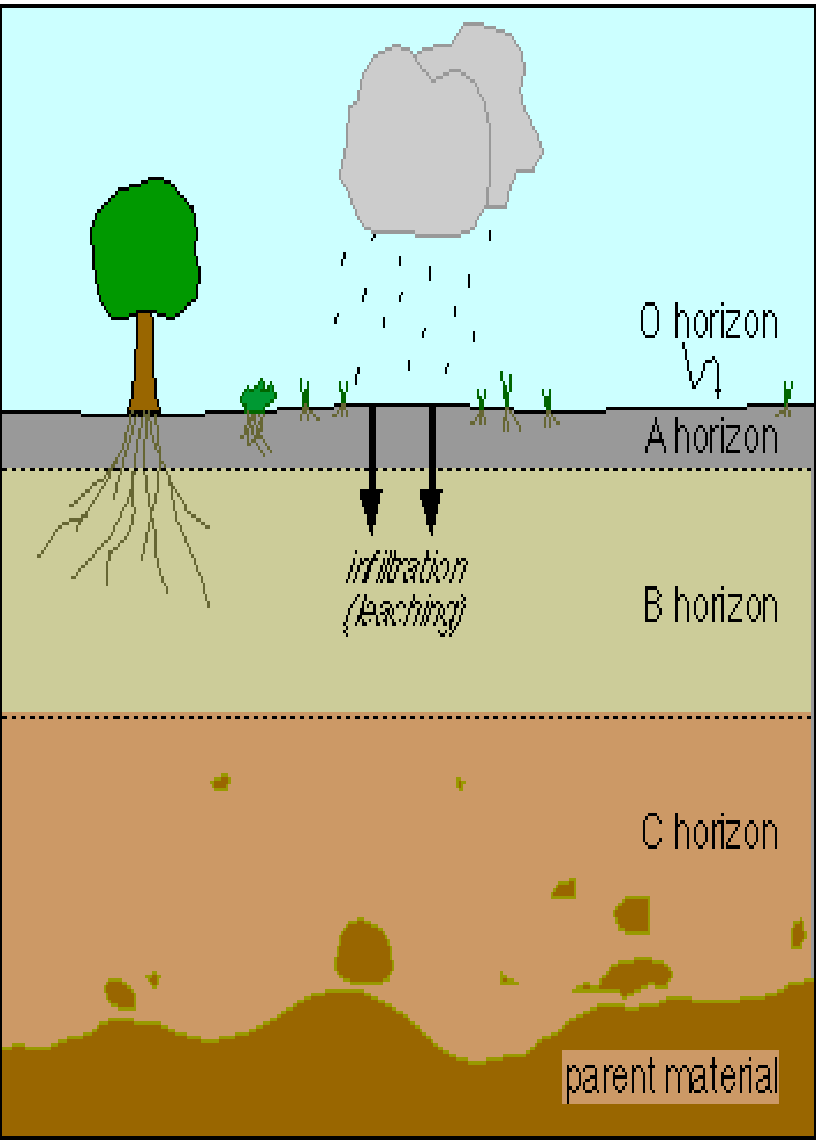
Effects on WATER

Excessive use of chemical fertilizers can pollute groundwater and water bodies mainly as follows:

- Leaching
- Eutrophication

- It is very common in developing nations that fertilizer use is concentrated in certain regions or districts.
- For example in Punjab, on an average 188 kg N/ha/year was used in 2012-13. While Jalandhar and Patiala used 228 kg N/ha/year, consumption in Hoshiarpur district was only 131 kg N/ha/year
- Thus in some regions where fertilizer use equals to or exceeds even that in developed nations, there exists the possibility of nitrate leaching of ground waters.

LEACHING

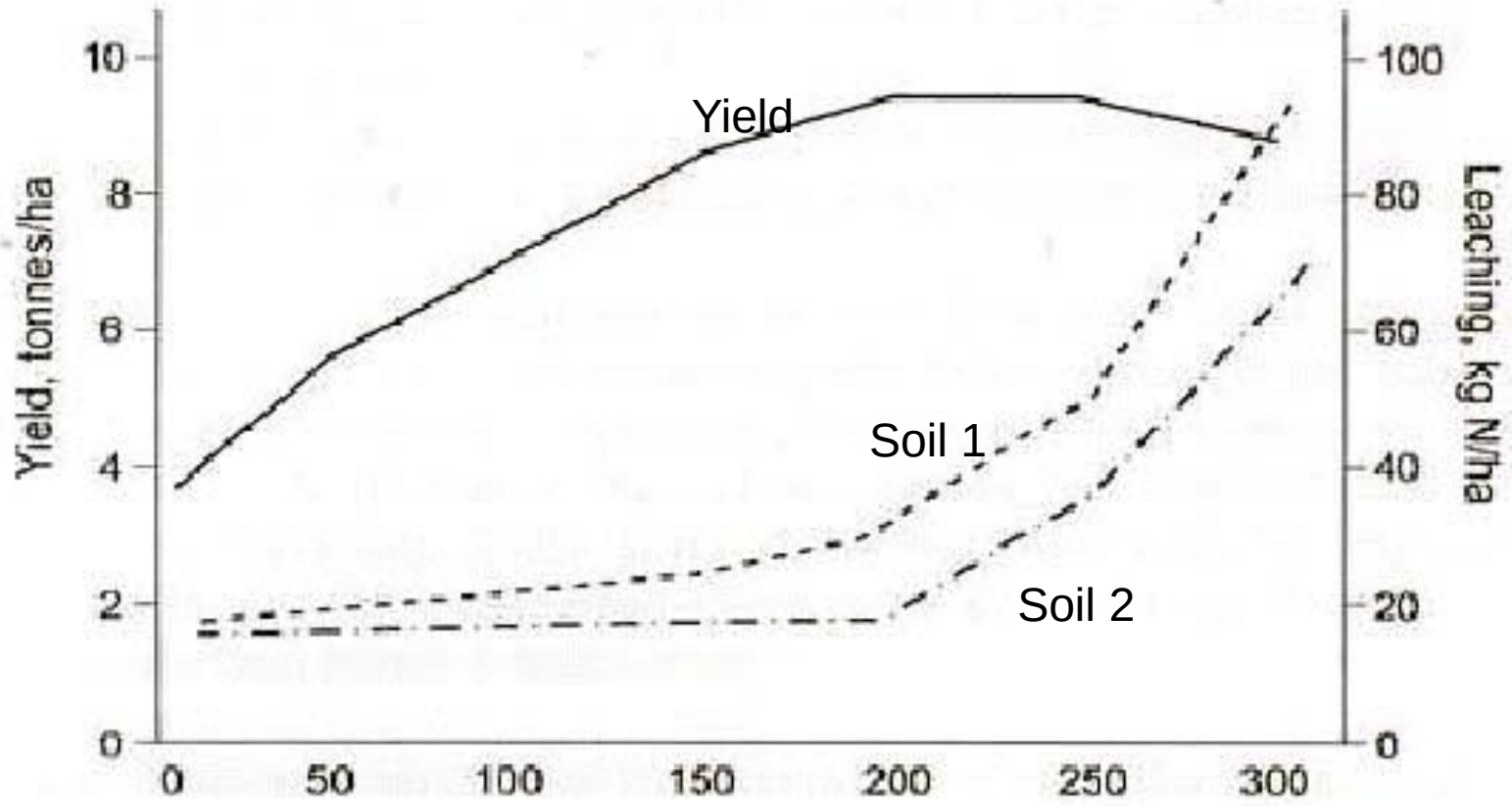


- Washing of water-soluble compounds present in fertilizers in excess amount out of root zone of soil .
- Movement of portion of colloids into lower layers or subsoil rock.

Leaching of nitrate-N

- **Concentration of nitrate-N in the soil profile**
- **Quantity of water passing through the profile**

Increased N leaching risk at higher N application rates



Source: Bockman et al, 1990.

Other losses

- Gaseous loss as nitrous oxides after denitrification.
- Volatilisation as ammonia.

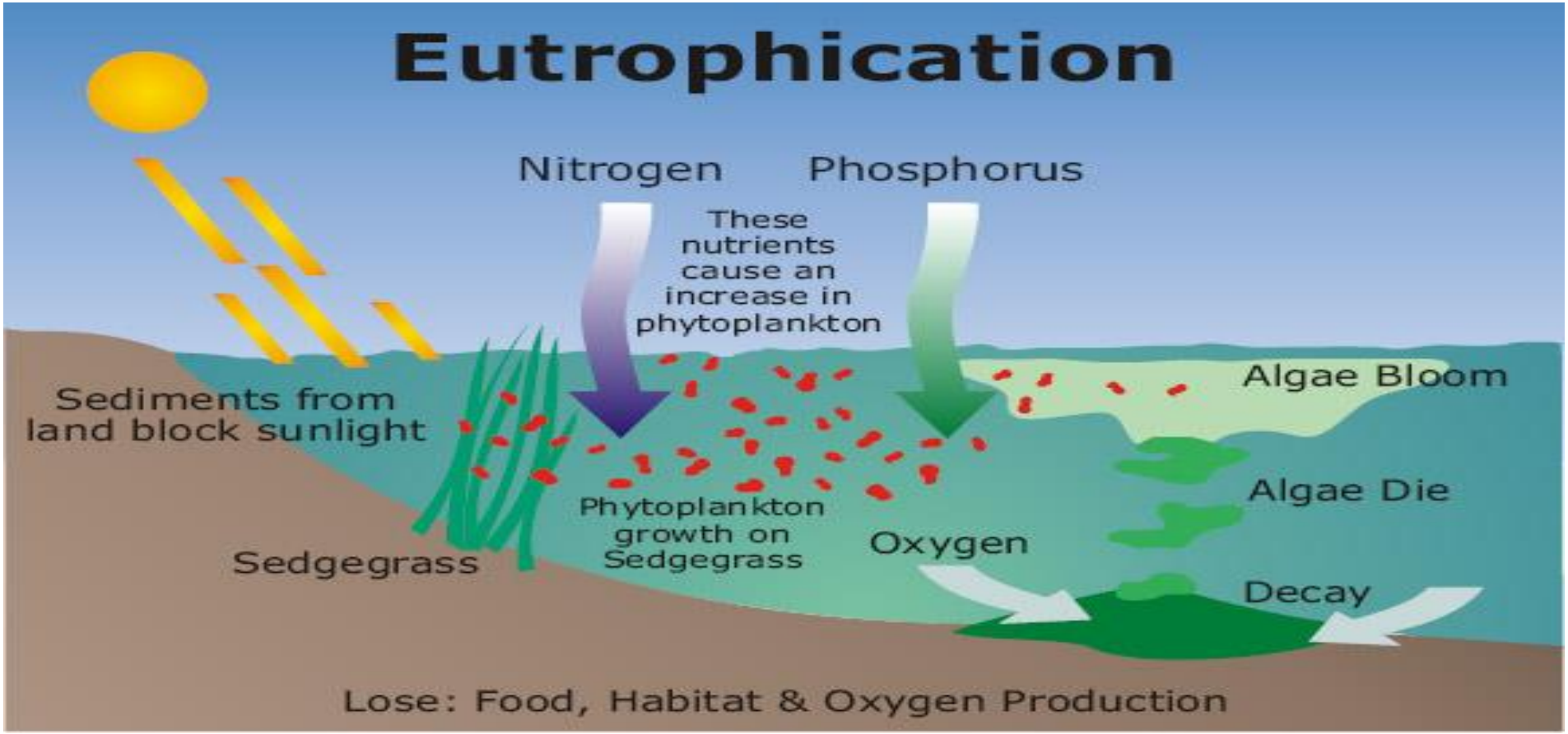
Fate of applied P

- Efficiency of applied P fertilizer is 20 -30 %
- Remaining - effectively converted to water insoluble form.
- Leaching - negligible.
- Soil erosion – important.
- P adsorbed on soil particles may be carried into surface waters.

Eutrophication

• It is the process of over-fertilization of a water body by nutrients that produce more organic matter than the self-purification process.

• Eutrophication can be natural process or it can be accelerated by an increase-of nutrient loading to a water body by human activity.



Presence of PTEs in common fertilizers

SOURCE	As	Cd	Zn	Cu	Pb	Ni
Urea	<0.04	<0.2	Nd	<0.6	<0.4	<0.2
DAP	9.9-16.2	4.6-35.5	10.3	<2.41	2.1-3.7	7.4-22.2
MOP	0.4	<0.2	4.59	<2.35	<0.4-10	<0.2
TSP	10.3	15.0	159	3.5	11	17

Tarafdar *et al* (2009)

Critical concentrations of heavy metals (mg kg^{-1}) in soils and their addition with the use of DAP

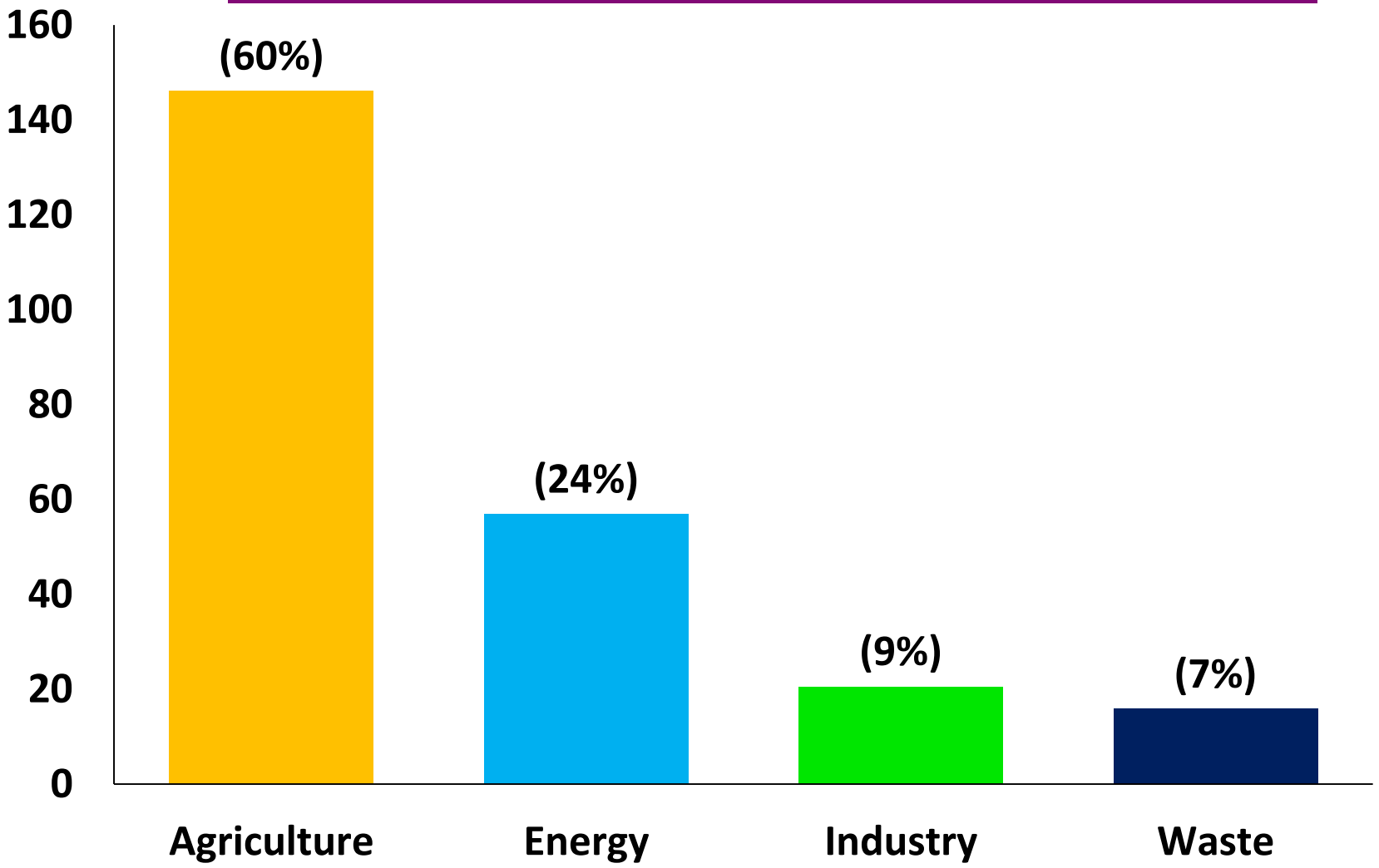
Element	Critical (Total)	Addition*
As	20-50	0.040
Cd	3-8	0.087
Ni	100	0.055
U	2-5	0.220
Pb	100-400	0.009

With the use of DAP @55 kg/ha over a period of 100 years

EFFECTS ON ATMOSPHERE

- Green house effect:- increase in nitrogen oxides due to nitrogenous fertilizers use like urea.
- Ammonia emission from fertilized lands, may be oxidized and turn into nitric acid, sulfuric acid from industrial sources, create acid rain after the chemical transformations.
- Nitrous oxide content in the atmosphere has increased by about 25 % over the previous century. About 1/3rd of this increase is thought to be due to agricultural practices.

N_2O emission and distribution by sector in '000 tons



Effects on human and animal health

- Nitrate *per se* is relatively nontoxic and is absorbed rapidly into the blood stream. A part of the ingested nitrate N can, however, be reduced to nitrite by gastrointestinal bacteria. Nitrite has an affinity for haemoglobin of the blood and converts it into methemoglobin by oxidizing iron of haemoglobin to ferric state.
- Methemoglobin acts as an asphyxiant because it cannot function in oxygen transport and, therefore, cellular anoxia can result.

- World Health Organization's drinking water standard is 10 mg NO_3^--N/l.

Cattle get affected by many diseases when they graze on fields, which have high content of chemical fertilizers such as:-

- Bioaccumulation in bodies of animals.
- Methaemoglobinemia
- Reproductive problems
- Cancer etc.

Urban agriculture and food safety

Urban and peri-urban agriculture contributes substantially to supply of vegetables and fodder in cities. However, researchers have found that urban soils contain high concentrations of PTEs, including Cd, Pb, Cr and Zn as these are often irrigatied with sewage water and/or industrial effluents .

High nutrient potential of sewage water allure the farmers to use it for irrigation.

Sewage water is a rich source of essential macro and micronutrients

Nutrient	Mean Concentration (mg L^{-1})	Amount added thro' one irrigation (kg ha^{-1})
Nitrogen	24.0	18.0
Phosphorus	2.57	1.92
Potassium	11.7	8.77
Sulphur	15.9	11.92
Zinc	0.061	0.045
Iron	1.464	1.098
Copper	0.029	0.021
Manganese	0.064	0.048

Rattan *et al* (2005)

- More than 10,000 hectare of land receives sewage water in Punjab.

- Land receiving sewage water has resulted in accumulation of heavy metals and ultimately higher uptake of these metals in plants.

Sewage Vs Tubewell Waters

Parameter	Sewage water	Tubewell Water
pH	7.6	7.8
EC (dS m^{-1})	3.2	0.2
SAR	18.6	2.2
Heavy Metals (mg L^{-1})		
Ni	2.23	0.03
Cd	0.031	0.001
Pb	0.42	0.03
Cr	0.71	0.04

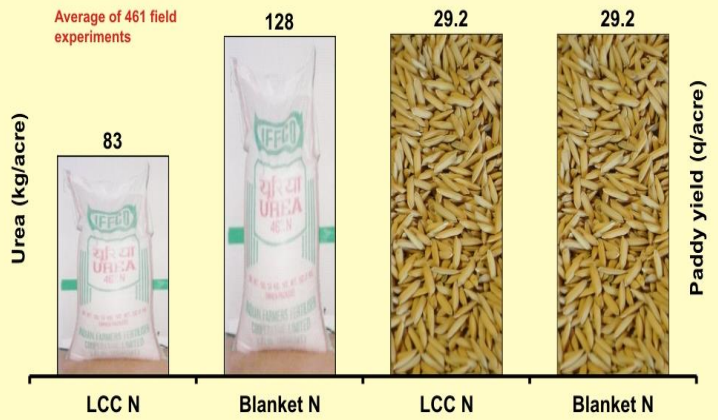
Lone *et al* (2003)

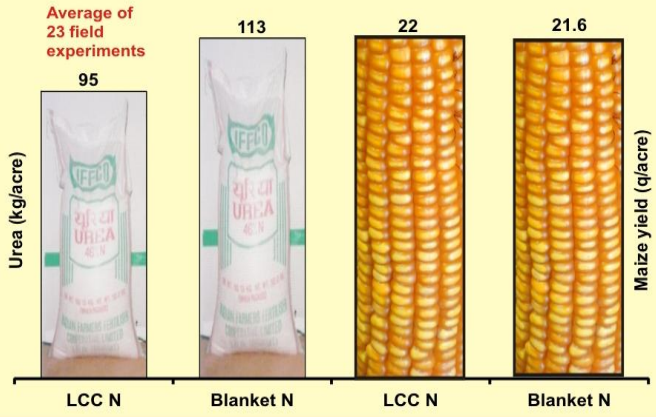
Management of fertilizers

- Know nutrient needs of your crop (SSNM).
- Apply fertilizers at proper time.
- Apply fertilizers only to healthy plants or reduce amount to unhealthy plants.

- Use crop residues and compost as source of nutrients.
- Break up fertilizer applications to synchronize with plant needs.

Leaf Colour Chart (LCC) for Need Based Nitrogen Management in Paddy and Maize

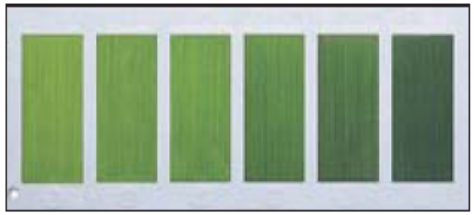




CINTRIN MEET

PAU leaf colour chart tech best for nitrogen mgmt

HT Correspondent
ludhiana@hindustantimes.com



The PAU-LCC is an effective and precise diagnostic tool to reduce escape of nitrogen from soil plant system. HT PHOTO

LUDHIANA: The Indo-UK Nitrogen Virtual Joint Centres have declared PAU's Leaf Colour Chart (LCC) technology as the best nitrogen management practice to improve nitrogen use efficiency.

They have also recommended it, ensuring the supply of PAU-LCC to all the farmers in India.

Dr Varinderpal Singh, senior soil chemist, PAU, presented PAU's work at a meeting of 'Cambridge India Network for Translational Research in Nitrogen (CINTRIN)' in Hyderabad, from October 5 to October 7, 2017.

More than 90 researchers from 46 research institutes across the globe discussed their works to improve the fertilizer nitrogen use efficiency.

The PAU-Leaf Colour Chart (LCC) was discussed as a diagnostic tool to reduce escape of nitrogen from soil plant system.

The senior soil chemist revealed that originally, International Rice Research Institute (IRRI-LCC) was adopted by the agri varsity for need-based fertilizer nitrogen management.

Discussing the benefits of PAU-LCC, Singh said that it could be used for precision nitrogen management in rice, wheat, maize and basmati rice to achieve potential yield.

THE INDO-UK NITROGEN VIRTUAL JOINT CENTRES RECOMMENDED THE USE OF PAU-LCC AND ENSURED ITS SUPPLY TO THE INDIAN FARMERS

OP Choudhary, head, soil science, PAU, said the department of soil science has adopted two villages, namely Bassian in Ludhiana and Mirjapur in Pathankot, with the support of CINTRIN and 'Atam Pargas', a social welfare council to educate the farmers to ensure judicious use of fertilizer nitrogen using PAU-LCC.

Varinderpal Singh said that farmers in the village Bassian are happy with the use of PAU-LCC in rice and have saved 50 to 75kg urea per acre in comparison to farmers' usual practice of applying 150kg urea per acre.

Varinderpal had earlier mentioned that excessive and untimely applied fertilizer nitrogen does not increase yield rather a large proportion of the nitrogen escapes from soil-plant systems to water bodies and the atmosphere, creating pollution problems.

"Nitrogen escaped to the atmosphere as oxides of nitrogen leads to depletion of ozone layer causing serious health hazards," he had said.

WHAT IS LCC

The leaf colour chart (LCC) is an innovative cost effective tool for real-time or crop-need-based N management in Rice, Maize and Wheat.

LCC is a visual and subjective indicator of plant nitrogen deficiency and is an inexpensive, easy to use and simple alternative to chlorophyll meter/ SPAD meter (soil plant analysis development). It measures leaf colour intensity that is related to leaf N status.

Ludhiana Tribune 24 October, 2017

PAU-Leaf Colour Chart helps cut use of urea

Pilot campaign of Atam Pargas and PAU

TRIBUNE NEWS SERVICE

LUDHIANA, OCTOBER 24

Excessive use of urea by the farmers in field crops is an issue of concern in Punjab. Mohinder Singh, in-charge, Atam Pargas Social Welfare Council, Raikot and Director, Guru Nanak Senior Secondary School, Bassian, took the initiative to educate farmers to reduce the consumption of urea using PAU-Leaf Colour Chart (PAU-LCC) technology under the guidance of Dr Varinderpal Singh, senior soil scientist, PAU, Ludhiana.

Four training camps for farmers and a series of street meetings were organised to sensitise the farmers to avoid excessive consumption of fertilisers and pesticides in agriculture in village Bassian. The PAU-LCC based urea applications were demonstrated in the fields of more than 60 farmers. At most fields, PAU-LCC leads to application of only 75 kg urea per acre and produced grain equivalent to farmers' practice of applying 150 kg urea/acre.

Farmer Kulwinder Singh was happy enough to invite farmers to visit his fields and see the grain filled spikes with the use of only 50 kg urea per acre by adopting PAU-LCC. He is proud of saving 50 bags of urea using PAU-LCC in rice and said would use saved urea in the forthcoming wheat crop too.

The farmers acknowledged PAU-LCC as simple, economical and farmer-friendly technology to save huge quantity of urea in the village. Amandeep Singh revealed that the use of PAU-LCC kept his field free from the attack of insects and pests.

Dr Nachhattar Singh, Director, Atam Pargas and ex-VC, Guru Kashi University, Talwandi Sabo, said that Atam Pargas has a network in more than 300 academic institutions in rural areas of the state and will extend its support to promote resource conservation technologies of the PAU in the interest of environment and society. He revealed that the Atam Pargas team is also instrumental in sensitising farmers to avoid burning rice straw and follow PAU recommendations for improving soil health and avoiding environmental pollution.

Dr Varinderpal Singh, Senior Soil Scientist, gives PAU-LCC demonstrations as Dr Tina Barsby, Director NIAB, UK, Dr Navtej Singh, Director of Research, PAU, and others look on. TRIBUNE PHOTO

Encourage the use of organic manure/ material to substitute a portion of the chemical fertilizers

- Farm Yard Manure (FYM)
- Vermi Compost
- Green Manure
- Bio Fertilizers
- Bio chars

FARM YARD MANURE

- Decomposed mixture of dung and urine of farm animals .
- Along with litter and left over material from roughages or fodder fed to cattle.

VERMICOMPOST

- **P**rocess of composting using various worms, usually red wigglers, white worms, and other earthworms.

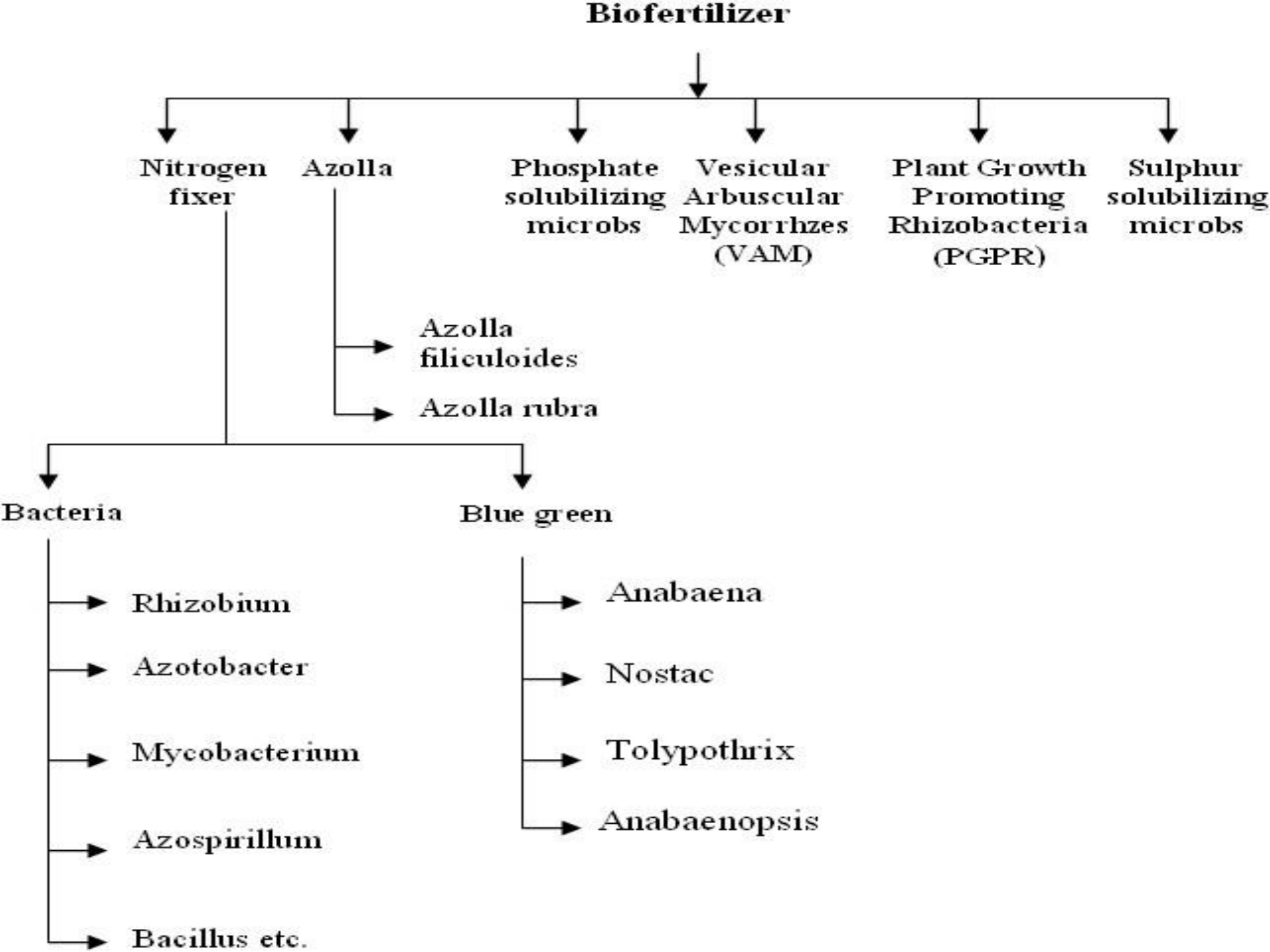
- Create heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast.

GREEN MANURE

- Growing crop, such as clover or grass, that is ploughed under soil to improve fertility.
- Can also reduce erosion.
- If crop is leguminous, add nitrogen to soil.

BIOFERTILIZERS

- Ready to use live formulations made of beneficial microbes
- On application, biofertilizers mobilize the availability of nutrients in soil and improve soil health


Biofertilizer
Nitrogen fixer
Azolla
Phosphate solubilizing microbs
Vesicular Arbuscular Mycorrhzes (VAM)
Plant Growth Promoting Rhizobacteria (PGPR)
Sulphur solubilizing microbs
Azolla filiculoides
Azolla rubra
Bacteria
Blue green
Rhizobium
Azotobacter
Mycobacterium
Azospirillum
Bacillus etc.
Anabaena
Nostac
Tolypothrix
Anabaenopsis

Benefits of INM

- ✓ Environmental friendly (through better NUE)
- ✓ Restoration of soil fertility and soil health
- ✓ Avoidance of pollution of soil, water and air
- ✓ Uses low cost technology
- ✓ Sustainable agricultural production
- ✓ Production of quality foods

MEAN GRAIN YIELD (t / ha) OF CROPS UNDER LONG TERM FERTILIZATION AND MANURING

LOCATION	CROPS	MEAN GRAIN YIELD (t /ha)			
		Unfertilized	100% NPK	100% NPK + FYM	150% NPK
Barrackpore (27 years)	Rice	1.6	3.9	4.1	4.3
	Wheat	0.8	2.4	2.5	2.9
Bhubaneswar (22 years)	Rice	1.6	2.8	3.5	3.0
	Wheat	1.4	3.0	3.7	3.3
Ludhiana (29 years)	Maize	0.4	2.6	3.2	2.5
	Wheat	1.0	4.8	5.0	4.9
Pantnagar (28 years)	Rice	3.1	5.3	6.0	5.3
	Wheat	1.5	3.8	4.5	4.1
Palampur (26 years)	Maize	0.3	3.2	4.6	4.0
	Wheat	0.3	2.5	3.3	3.0

Pesticide Use in Agriculture

- Modern agriculture practices have also relied on pesticide use.
- With the introduction of DDT in the early 40s, non-chemical methods of pest control dwindled.
- Today, over 100,000 chemicals including insecticides, fungicides, herbicides, acaricides and rodenticides are in use throughout the world for pest control.

Effect of excessive use of pesticides on environment

- Large amounts of pesticides reach the soil, either as direct application, from fall-out and from aerial spraying.
- Excessive use of pesticides can contaminate soil ecosystem and pose threat to the balance equilibrium among various groups of microorganisms and components in soil.
- Important process like mineralization, nitrification and phosphorus recycling are dependent much on these balanced equilibriums.

Continued….

High concentration of these pesticides

i) disturb the presence of soil enzymes, which play a key role in many soil processes and organic matter turnover.

ii) result in their absorption by plants leading to various ill effects in the entire ecosystem.

Continued….

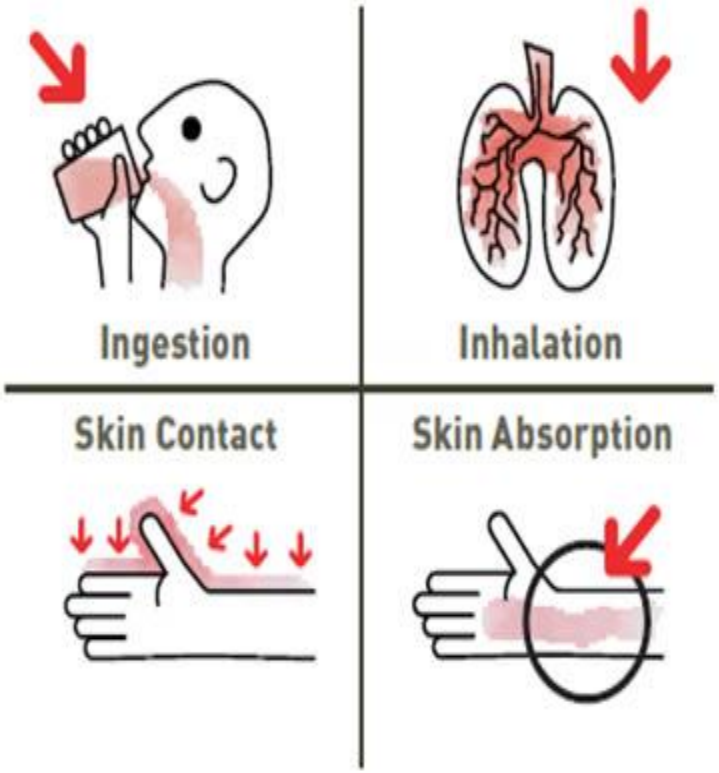
- Pesticides drained to water bodies causes water pollution hence water in river and lakes gets polluted which becomes hazardous to aquatic animals like fishes.
- Pesticides may also washed down to ground water which pollute drinking water.
- During the spraying of pesticides it may reach in to atmosphere and pollute the air.
- Pesticides may kill the friendly insects along with the inimical insects during its action.

Continued….

- Repeated use of pesticides may produce immunity or resistance in insects. Resistance has been observed in houseflies, mosquitoes etc.
- Certain pesticides such as DDT, BHC etc persist in the environment, accumulate in blood, milk and fat of animals.
- Beyond certain permissible levels, they are very dangerous if their intake exceed a maximum limit to human beings and animals

Pesticides entering human body

- Pesticides can enter the body through inhalation of aerosols, dust and vapour that contain pesticides.
- The effects of pesticides on human health depend on the toxicity of the chemical and the length and magnitude of exposure.
- Farm workers and their family experience the greatest exposure to agricultural pesticides through direct contact.



Pesticide residues in food commodities in India

- In India, 51% of food commodities are contaminated with pesticide residues and out of these, 20% have residues above the maximum permissible levels
- Long term, low dose exposure to pesticides are being increasingly linked to human health effects such as immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer.

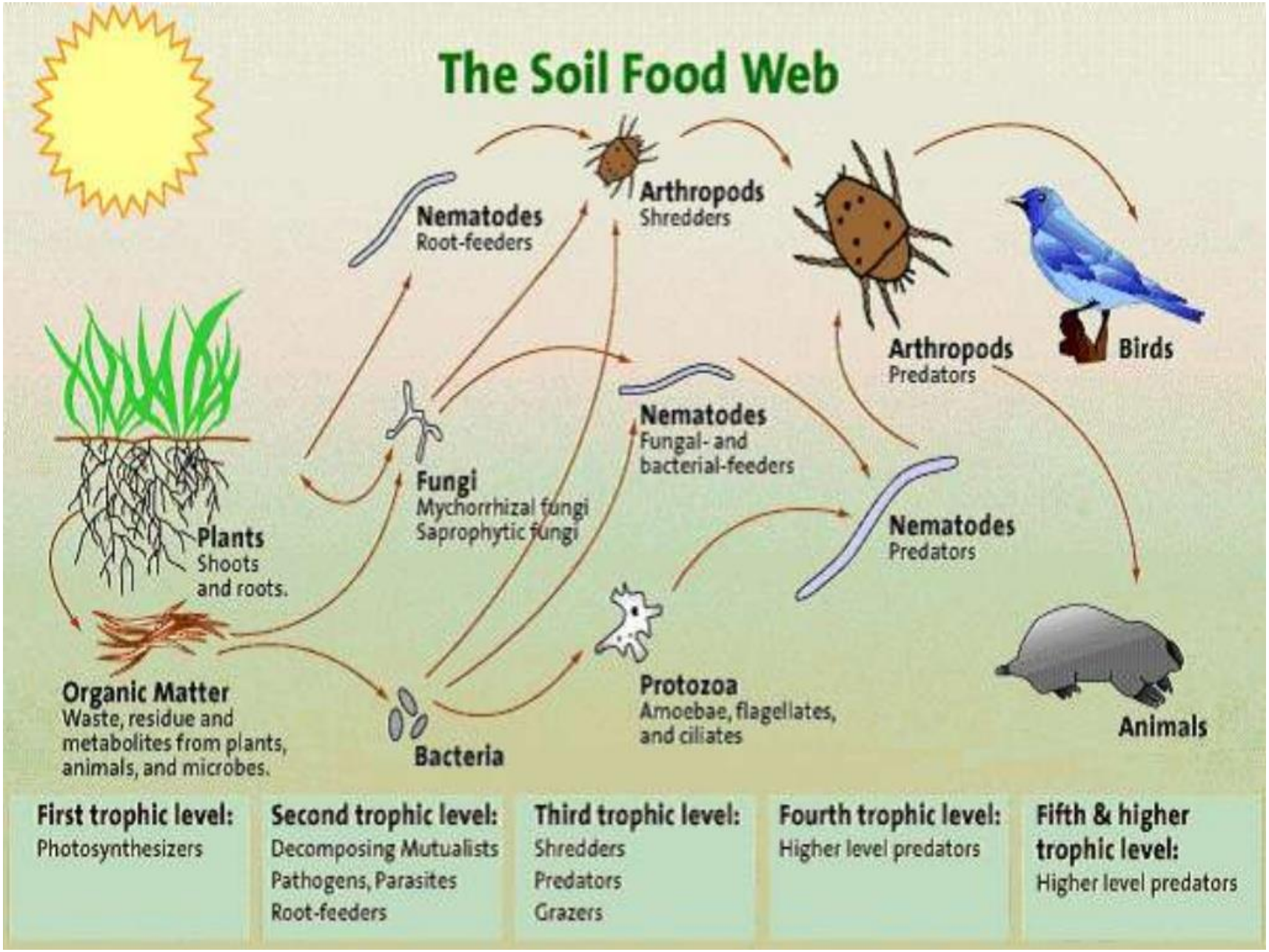
Pesticide residues in food commodities in India

In a study based on selected food commodities collected from different states of India

- DDT residues were found in about 82 % of the 2205 samples of bovine milk collected from 12 states
- About 37 % of the samples contained DDT residues above the tolerance limit of 0.05 mg/kg
- The proportion of the samples with residues above the tolerance limit was maximum in Maharastra (74 %) followed by Gujarat (70 %), Andhra Pradesh (57 %), Himachal Pradesh (56 %) and Punjab (51 %).
- In 186 samples of 20 commercial brands of infants formulae showed the presence of residues of DDT and HCH isomers in about 70 and 94 % of the samples

Health effects of pesticides in Punjab

- The incidence of cancer, asthma and diseases of kidney, skin and digestive tract has increased by 20-25% in Punjab. However, no scientific data base is available linking pesticide use and occurrence of these diseases.
- The food we eat, the water and milk we drink are contaminated with one or other chemicals. So much so the traces of BHC, endosulphan, DDT & HCH, the banned pesticides have been found in the most safe & sacred mother's milk in many cases in Punjab.


The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Nematodes
Fungal- and
bacterial-feeders
Fungi
Mychorrhizal fungi
Saprophytic fungi
Plants
Shoots
and roots.
Nematodes
Predators
Organic Matter
Waste, residue and
metabolites from plants,
animals, and microbes.
Bacteria
Protozoa
Amoebae, flagellates,
and ciliates
Animals
First trophic level:
Photosynthesizers
Second trophic level:
Decomposing Mutualists
Pathogens, Parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth & higher
trophic level:
Higher level predators

Effect on AIR

- Pesticides can contribute to air pollution.
- Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas.
- Weather conditions at the time of application as well as temperature and relative humidity change the spread of the pesticide in the air.

Kerala's Endosulfan Tragedy

- The UNO classifies Endosulfan as highly dangerous insect killer and banned in 62 countries.

- Endosulfan, a highly toxic organochlorine pesticide was sprayed in the cashew plantations in Kasaragod District sine 1976, till 2001 regularly three times every year.

- The aerial spraying of Endosulfan was allegedly undertaken to contain the menace of the tea mosquito bug.
- By 1990s health disorders of very serious nature among the human population came to the lime light.
- Children were found to be the worst affected with congenital anomalies, mental retardation, physical deformities, cerebral palsy, epilepsy etc

Hon'ble Supreme Court passed interim order on May 13, 2011 to ban the production, distribution and use of endosulphan in India

The ideal pesticide

- The ideal pest-killing chemical has these qualities:
- Kill only target pest.
- Not cause genetic resistance in the target organism.
- Disappear or break down into harmless chemicals after doing its job.
- Be more cost-effective. It would stay exactly where it was put and not move around in the environment.
- There is no such thing!

- Nevertheless, there are encouraging trends and continuous endeavors towards phasing out the toxic and persistent group of pesticides.

- Some new molecules are being developed which are biodegradable and having low mammalian toxicity, low residual life and better compatibility with non-target organisms.

Integrated pest management (IPM)

Combines biocontrol, chemical, and other methods

Involve:

- **Biocontrol**
- **Pesticides**
- **Close population monitoring**
- **Crop rotation**
- **Transgenic crops**
- **Alternative tillage**
- **Mechanical pest removal**

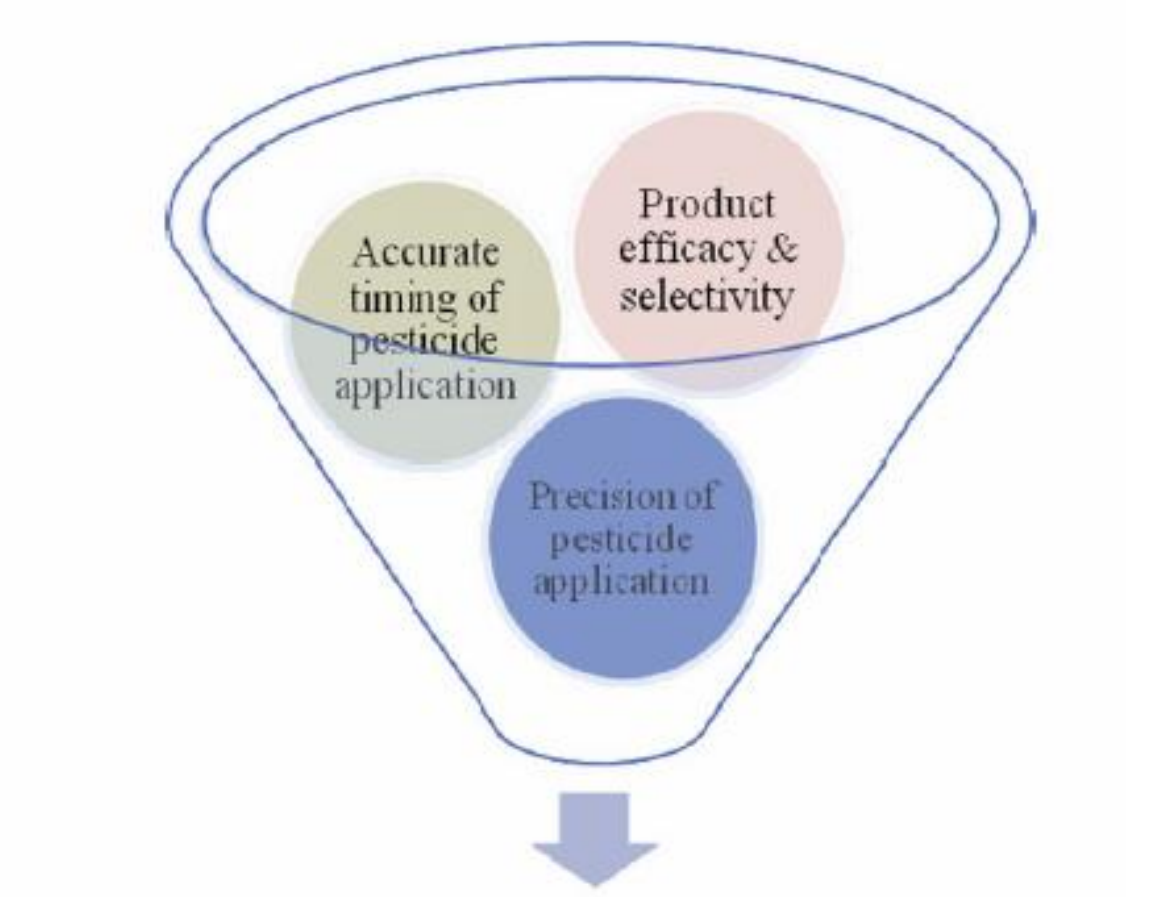
Biological control

- **Synthetic chemicals can pollute and have health hazards.**

- **Biological control (biocontrol) avoids this.**
- **Biocontol entails battling pests and weeds with other organisms that are natural enemies of those pests and weeds.**

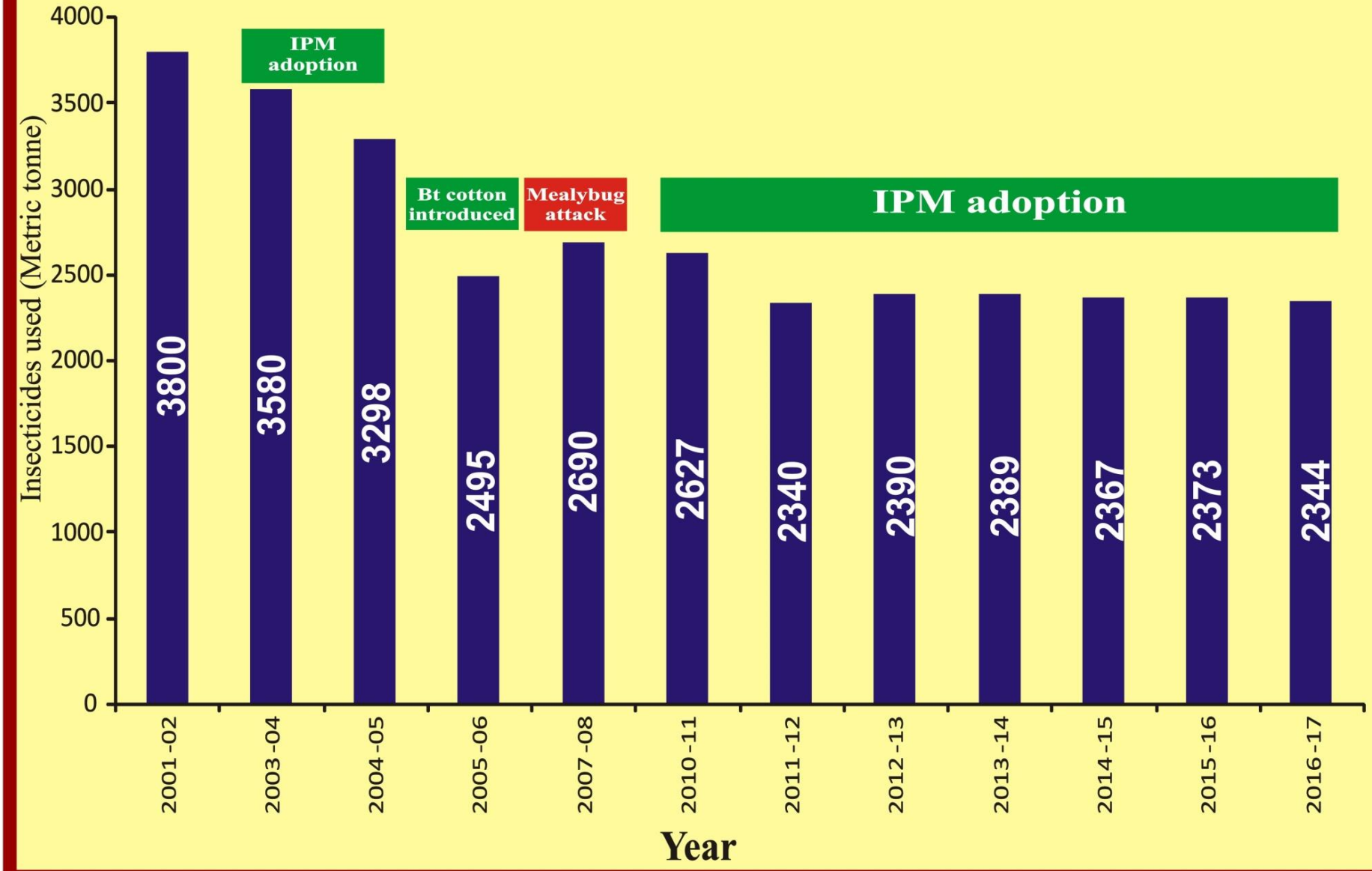
- ***(“The enemy of my enemy is my friend.”)***

Critical factors affecting the safety of pesticide application

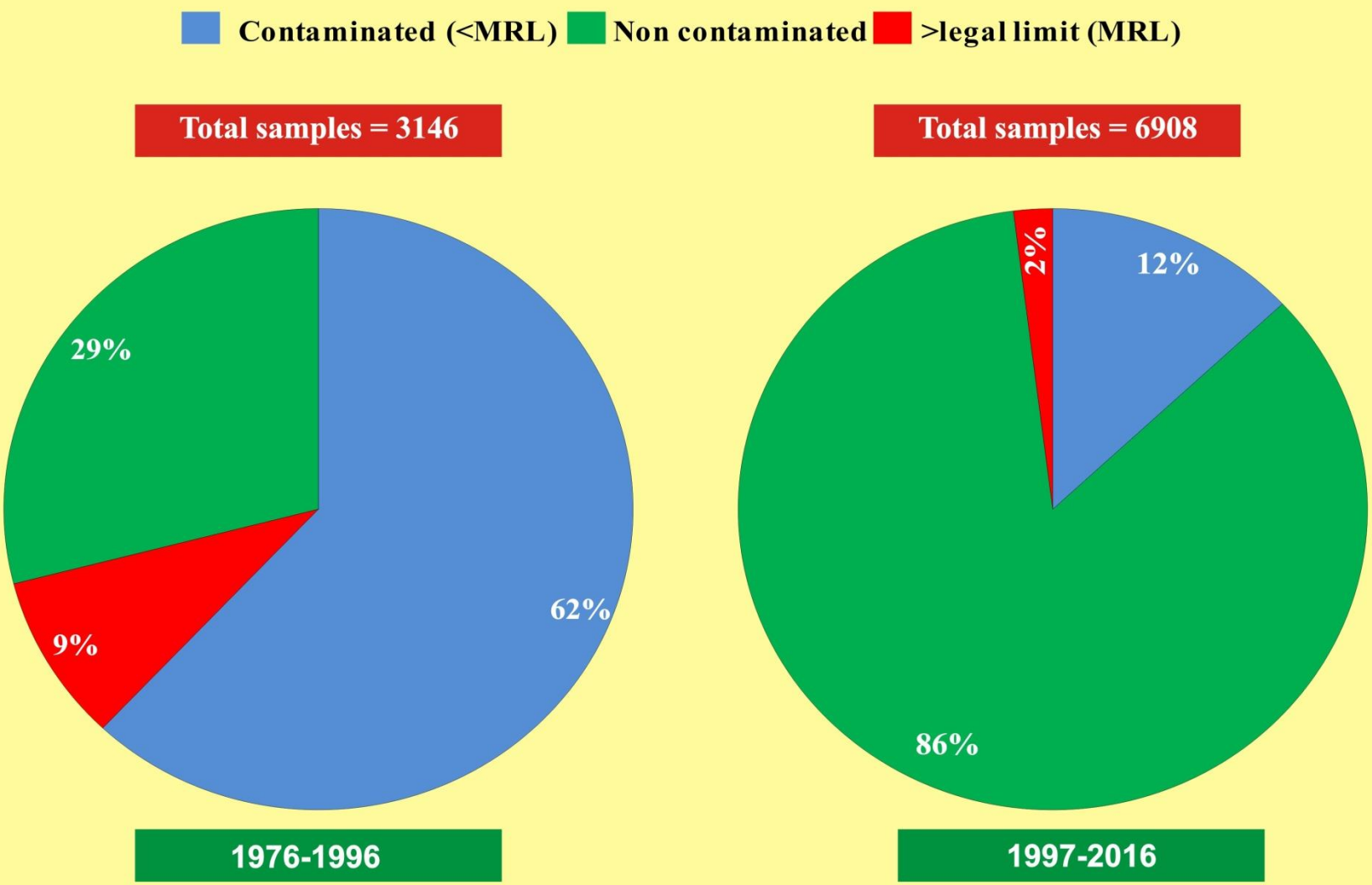


RATIONAL PESTICIDE USE

Consumption of insecticides in Punjab



Status of Pesticide Residues in different Food Commodities in Punjab



Status of pesticide residues in different food commodities in Punjab

Year	No. of sample analyzed	No. of samples with pesticide residues	No. of samples above MRL
1976-1980	634	551 (86.9%)	238 (37.5%)
1981-1990	1507	1459 (96.8%)	284 (18.8%)
1991-2000	1471	1354 (92.0%)	649 (44.1%)
2001-2010	2216	407 (18.4%)	88 (4.0%)
2011-2017*	5224	427 (8.2%)	66 (1.3%)

***up to August, 2017**

CONCLUSIONS

- To feed billions, sustaining high level of productivity requires use of adequate fertilizers and pesticides but their excessive and indiscriminate use can have serious environmental and health implications
- Fertilizers be applied on the basis of soil testing and plant analysis adopting INM and SSNM approach
- 4R nutrient stewardship will ensure greater productivity and profitability without causing any harm to environment
- IPM – a solution for rational pesticide use
  - green biodegradable molecules
  - low mammalian toxicity,
  - low residual life
- Fertilizers and pesticides are necessary (evils)

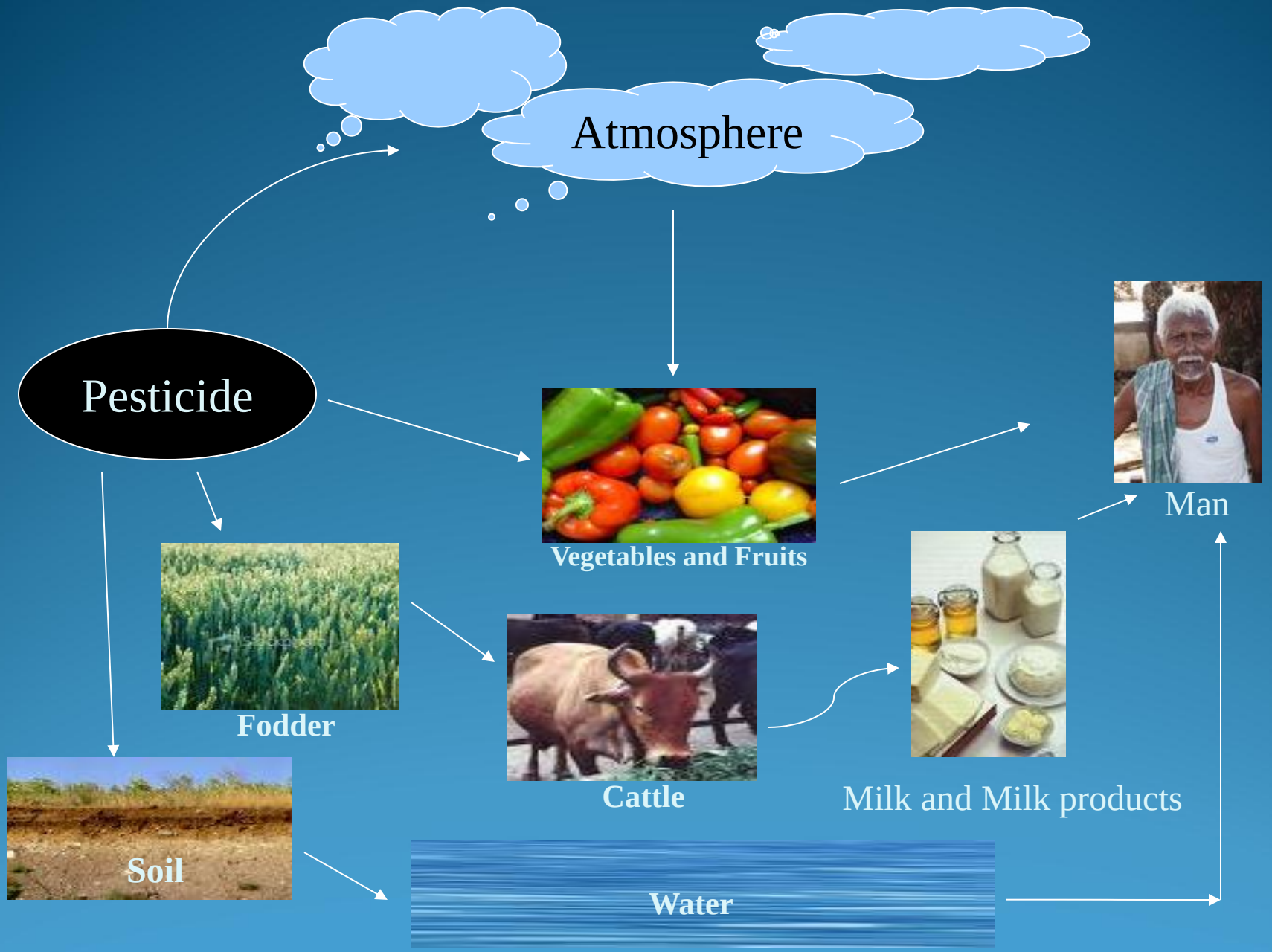
Chemistry

Laws &
Regulations

Human Health

Disposal

Ecosystems



Cycling of Pesticides in the Environment

Health effects of pollution

Air pollution

Water pollution

Headache
Fatigue

Respiratory illness

- Bacteria
- Parasites
- Chemicals

CO

Particulate matter

Nerve damage

Ozone

Lead

SO_2
NO_X

Cardio-vascular illness

Volatile organic compounds

Gastroenteritis

Cancer risk

Nausea

Skin irritation

Pesticides

Soil contamination