Social Cost of Groundwater Pollution in India

Current Status, Challenges and Directions for future work

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Contents

Studies

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Raychoudhury T. and Krishnan S., 2007, Coastal Salinity in Junagadh, Gujarat, in Proceedings of International Groundwater Conference, Coimbatore

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Krishnan S., 2010, Groundwater quality in India: extant, impacts and mitigation, Report submitted to Planning Commission over impacts of Groundwater studies

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Acknowledge: International Water Management Institute, Sir Dorabji Tata Trust, Sir Ratan Tata Trust, Public Health Foundation of India, Apollo Hospitals, Planning Commission

Why look at the Social Cost of GW Pollution?

There is currently investment from government, donors and private sector on addressing pollution problems

Various methods, technologies are being adopted

What is the impact of these measures?

What problems are they solving?

What social benefits are being created from these measures?

Social Cost of GW Pollution will be one component of this benefit

Disease Burden of Water Quality Problems in India

Quality problems	No. Districts	Population affected/exposed	Cause	Impact
Salinity	137	No estimates available	Inherent(geogenic)/Manmade (eg. coastal saline intrusion due to overpumping)	Kidney stones due to poor hydration in such areas (Rs. 7500 cost per family per year)
Fluoride	203	65 million	Inherent(geogenic), but aggravated also by over-exploitation; increased by malnutrition	Fluorosis; DALY = 38.5 per 1000 population; > Rs. 5000 per capita annual expenses
Arsenic	35	5 million in WB; more in Assam, Bihar	Complex geogenic processes not yet well understood; but suspected to be related to excessive use and related water table fluctuations; increased by malnutrition	Arsenicosis ; DALY 5-27 per 1000 population
Iron	206	No good estimates	Geogenic mainly;	Iron overload; Cirrhosis; suspected Diarrhoel linkages; Cardiac linkages
Biological	No good estimates	No good estimates	Related to poor sanitation and hygiene practices; increased by malnutrition	Diarrheal problems; DALY > 22 million years annually; total 4,50,000 deaths annually
Agrochemicals	No good estimates	No good estimates	Related to pesticide/fertilizer use in agriculture	Multiple impacts; not understood well
Industrial effluents	No good estimates	No good estimates	Due to effluents from Industries	Multiple impacts; not understood well

Source: Krishnan, 2009

Total pollution load

Total pollution Load into Aquifers (mainly)
= Load from Industries + Load from Agriculture + Load from Domestic waste

But aquifer pollution happens due to variety of processes eg. overpumping and salinity ingress

Current country level on macro level does not match with micro studies

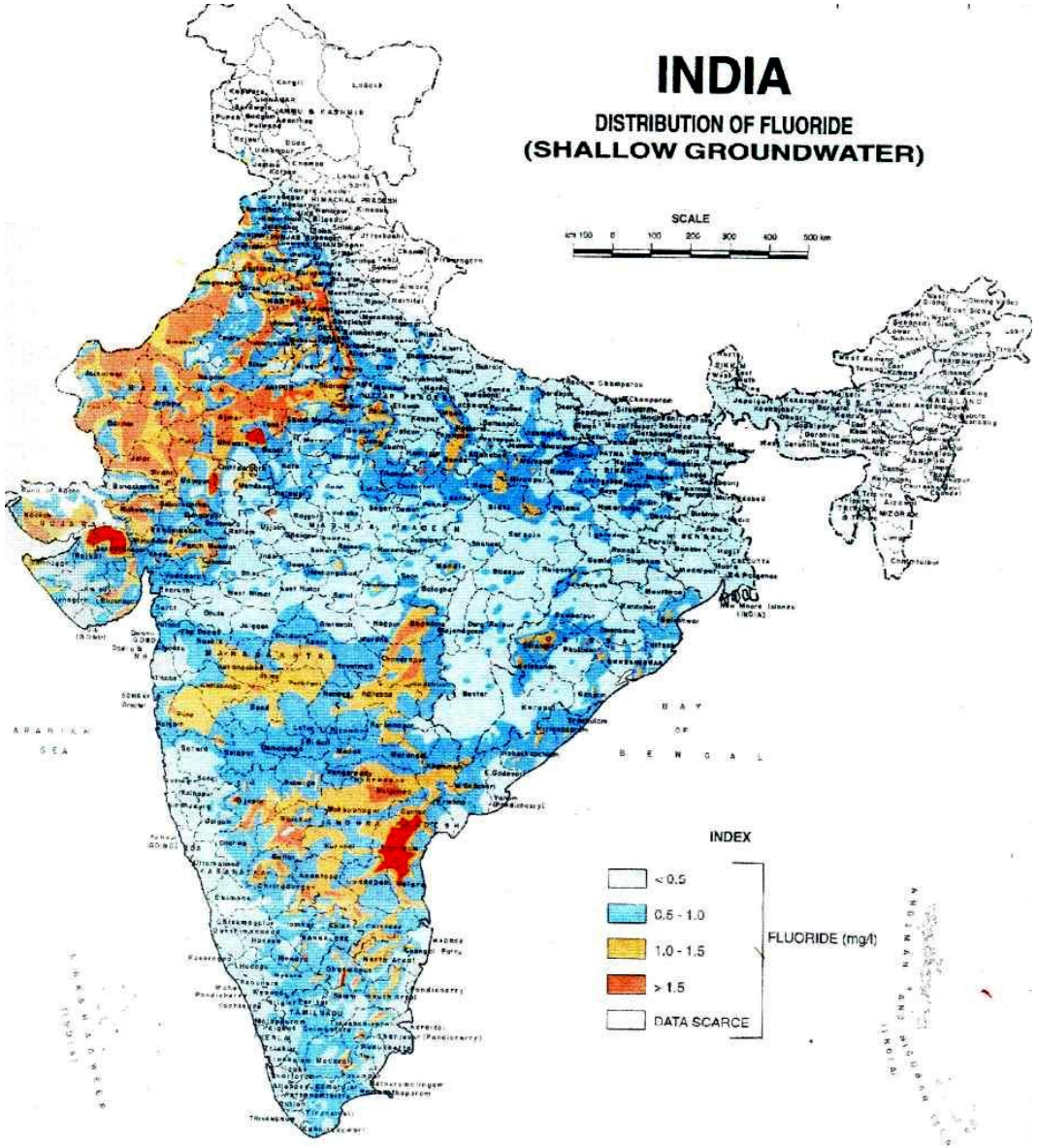
Then, how do we arrive at an overall picture ?

The rate of pollutant load is a combination of direct inputs and due to indirect effects eg. pumping, well deepening, induced geochemical process

Social Cost of Fluorosis

Social Cost of Fluorosis

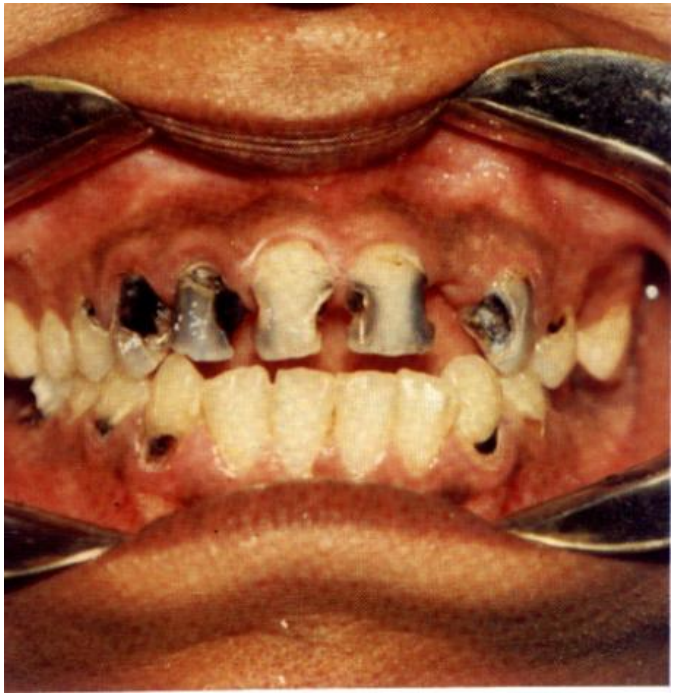
- Hydro-Fluorosis causes by consumption of high Fluoride in water
- Not just Dental and Skeletal Fluorosis, but variety of problems with brain, liver, kidney, heart diseases
- Estimates vary from 10 to 65 million people exposed
- DALY of 38.5 per 1000 population (NEERI, 2007)

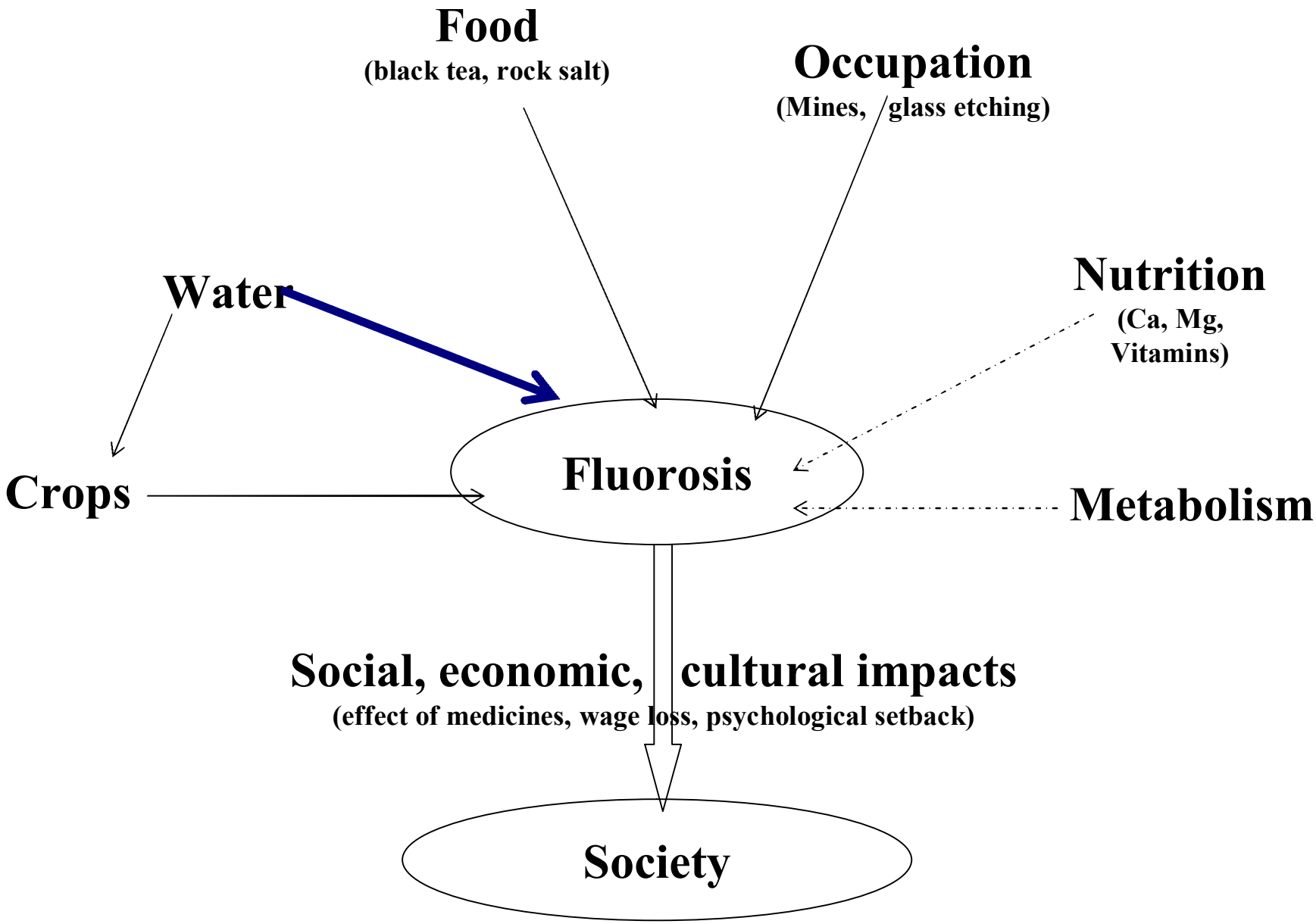

INDIA
DISTRIBUTION OF FLUORIDE
(SHALLOW GROUNDWATER)
SCALE
INDEX
< 0.5
0.5 - 1.0
1.0 - 1.5
> 1.5
DATA SCARCE
FLUORIDE (mg/l)

Source: CGWB

Stages of Fluorosis

- Dental
- Skeletal
  - Genu Valgum
  - Skeletal
  - Neurological




Food
(black tea, rock salt)
Occupation
(Mines, glass etching)
Water
Nutrition
(Ca, Mg, Vitamins)
Crops
Fluorosis
Metabolism
Social, economic, cultural impacts
(effect of medicines, wage loss, psychological setback)
Society

Fluorosis mitigation programmes

- More than 50% of Fluoride intake can be through food grown locally
- Fluorosis is linked much with climatic and nutritive factors
- Teaching of Fluorosis is not present in current Indian medicine or engineering literature
- Fluorosis patients can incur high costs (wage + medicine losses)

Social cost of Fluorosis

Cost calculation:

- Medical cost = Medicine cost + Doctor's cost
  (cost taken in ranges)

- Wage loss = If unable to work because of Fluorosis, then total wage loss (partial or full)

Costs ignored:

- Impact on livestock's productivity
- Cumulative labour loss in society
- Impact on village GDP
- Intangible costs eg. social stigmas

Medical and Wage loss costs

	North Gujarat (in 2002)	Dausa (in 2005)	Kolar (in 2005)	North Karnataka (in 2005)
per capita annual medical cost	Rs. 861	Rs. 1489	Rs. 2807	Rs. 1724
per capita annual wage loss	Rs. 4593	Rs. 19741	Rs. 8719	Rs. 12857
afflicted no/household	1.1	1.3	1.7	2.3
cost/annual income	26 %	6 %	21 %	16 %

Example of Total Burden From Fluorosis

DDWS Data: 25,069 habitations all over India affected

Taking Average of 625 population per habitation,

Total population exposed = 15.6 million

With Rs 5000 per capita per year social cost,

Total Potential Social Cost Annual = Rs. 7834 crores
(a rough estimate, not to be quoted)

Problems with estimate:

Habitation data; AP reported as almost no Fluoride;
Incidences of Fluorosis cases; Variable Social cost

Example of Total Burden From Fluorosis Cost of avoiding this burden

Per capita 20 l / day

Cost of providing water: Rs 0.2/litre

Total cost per person = Rs 1460 /year

Total cost for 25 million exposed persons:

= Rs 2287 crores/year

Further action of nutrition enhancement is necessary to neutralize the entry of Fluoride through food

Fluorosis Mitigation Programmes in India (1970s till now)

- Most Fluorosis mitigation programmes have been water supply programmes
- We can make 4 categories of these mitigation programmes:
  - Defluoridation at community level
  - Defluoridation at individual level
  - Water supply at regional level
  - Clinical and focussed patient approach

Defluoridation at community level

- Started mainly as De-fluoridation programmes
- Nalgonda filter (using Lime and Alum) in 1970s … NEERI
- Reverse Osmosis (RO) with proper membrane can remove Fluoride ions

Defluoridation at community level

- Based on Nalgonda technique-lime and alum method.
- Addition of aluminum salts, lime and bleaching power followed rapid mixing, flocculation, sedimentation, filtration and disinfection.
- However, none of the 300 plants installed all over India are functioning now

Source: R Reddy

Defluoridation at community level

Reasons for Failure of Nalgonda plants

- Community failed to appreciate reason for water treatment
- No involvement of Health agencies in planning
- Required high maintenance cost and time
- Difficult to recover costs for maintenance
- Aesthetic problems with treated water

RO for Defluoridation at community level

- Reverse Osmosis technology developed in 1960s for desalination and military purposes

- Based on differential ion concentrations across a semi-permeable membrane. Solute permeates through the membrane due to pressure from high to low concentration compartment

- Started to be used in India since 1990s for drinking water purposes

- Currently large market of domestic and large units

- The most widely used technology for bottled water

Successfully operating RO plants in south Gujarat

	Minimum	Average	Maximum-
Capacity	250 lph	560 lph	1000 lph
Storage	200 litres	2000 litres	6000 litres
Plant cost	1.25 lakhs	2.32 lakhs	5 lakhs
Cost/litre	0	Re 0.28	Re 0.6
Prod/day	300 litres	1200 litres	2500 litres
Buyers in village	30	86	325
Reach	10%	42%	100%

Suppliers of plant are varied (ISO, non-ISO)

Reach within village shows wide variation,

Off-shoot water suppliers cover surrounding villages,

Non-users have very poor drinking water facilities

Variability in size, cost/litre, % of reach and production

Debates with RO

- Cost/litre
- Effluent disposal
- Does it really treat for required contaminants?
- Maintenance
- Is it safe for health?
- Is it really required?

Treatment aspects of RO water

- RO treats only according to the specific membrane capacity
- Pre and post treatment is required
- Although pure distilled water can be harmful for health, NRC, 1983 reports no health based guideline for RO water
- Effluent for RO should be disposed properly, but currently no official safety standards exist in India

Domestic Defluoridation Programmes

- Research in 1980s to overcome problems with Nalgonda technology
- Search for low cost, low maintenance, no energy
- IIT Kanpur and UNICEF identified Activated Alumina (AA) as a suitable technology
- AA adsorbs Fluoride ions to limited capacity
- Beyond this capacity, AA needs to be “regenerated”
- Cost of AA now is around Rs 80/kg
- Adsorption capacity is around 5000 mg per Kg of AA

Domestic Defluoridation Programmes

- Activated Alumina
  - Minimum of 1mg/g adsorption. Requires regeneration every 4-5 months
  - New materials with 8-9 mg/g adsorption
  - Al-Fl complexes a health concern
  - Has wide industry application, so is low-cost and available
  - AA filters not available in market
  - No electricity required

Two main programs for AA are SWACH and Mytry

Domestic Defluoridation Programmes

- SWACH and Mytry

UNICEF and IITK tested the AA DDU filters and implemented in 2 locations

Awareness programmes, village regeneration centres

Mytry later transitioned into filter manufacturing company

Currently some maintenance of filters happens in Rajasthan, but not widespread

Domestic Defluoridation Programmes

Reasons for failure of Domestic Defluoridation Programmes:

- Addresses Fluoride only, whereas people are immediately concerned about TDS, taste, odour, bacterial contamination
- Maintenance aspect is intensive; services may be required
- Reinforcement from doctors absent
- Results not quick and reversal not very fast except for gastro problems

Water supply at regional level

- Many piped water supple schemes in operation now

- Some are in successful operation, but most provide intermittent water

- O and M of schemes difficult; also assurance of the source

- Some positive results observed from our field studies showing hope with long term good water supply; New generation is safer from Fluorosis ; the food route is still present

Clinical and focussed patient based approach

Dr. AK Susheela

Nutrition : Amla, Anti oxidants, … preventing food with high Fluoride eg. tea … N delhi, Karbi Anglong, Dungarpur

Dr. SK Gupta

Asorbic acid (Vitamin C) and other nutrition measures. Reverse DF in children…. Jaipur

Clinical and focussed patient based approach

Dr. T Chakma

Mainly nutrition based measures – Chikora Bhaji – high Ca, reversed high SF in children … Mandla, Jhabua

Dr. R Reddy
Identified Ca, Mg , Vitamin C as main nutrition deficiencies for Fluorosis patients …. Prakasham, Nalgonda

Observations from mitigation experiences

- Water supply program alone will not address Fluorosis mitigation

- Demand needs to be generated for need for safer water

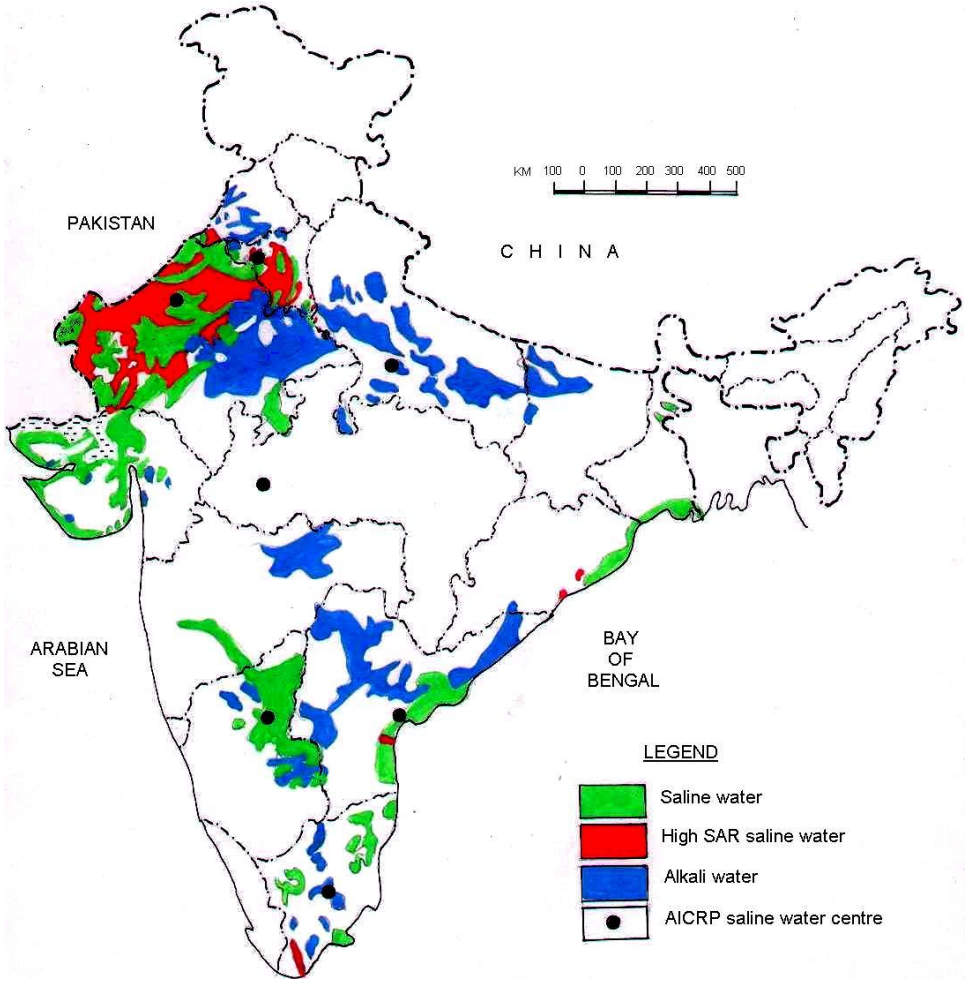
- High costs might exclude some communities

- Apart from water, nutrition and food is very important

- Expectation of mitigation needs to be clearly defined:
  a) Which symptoms can be reversed
  b) To what degree can reversal happen
  c) What time frames will this take
  d) To what confidence will this happen

Social Cost of Salinity

Example of Salinity Impact



Source: ICAR Studies

Ailments caused/attributed to saline water

Renal stones (kidney stones) and related diseases

Skin diseases – eczema, scabies (particularly in winter), fungal patches, psoriasis etc.

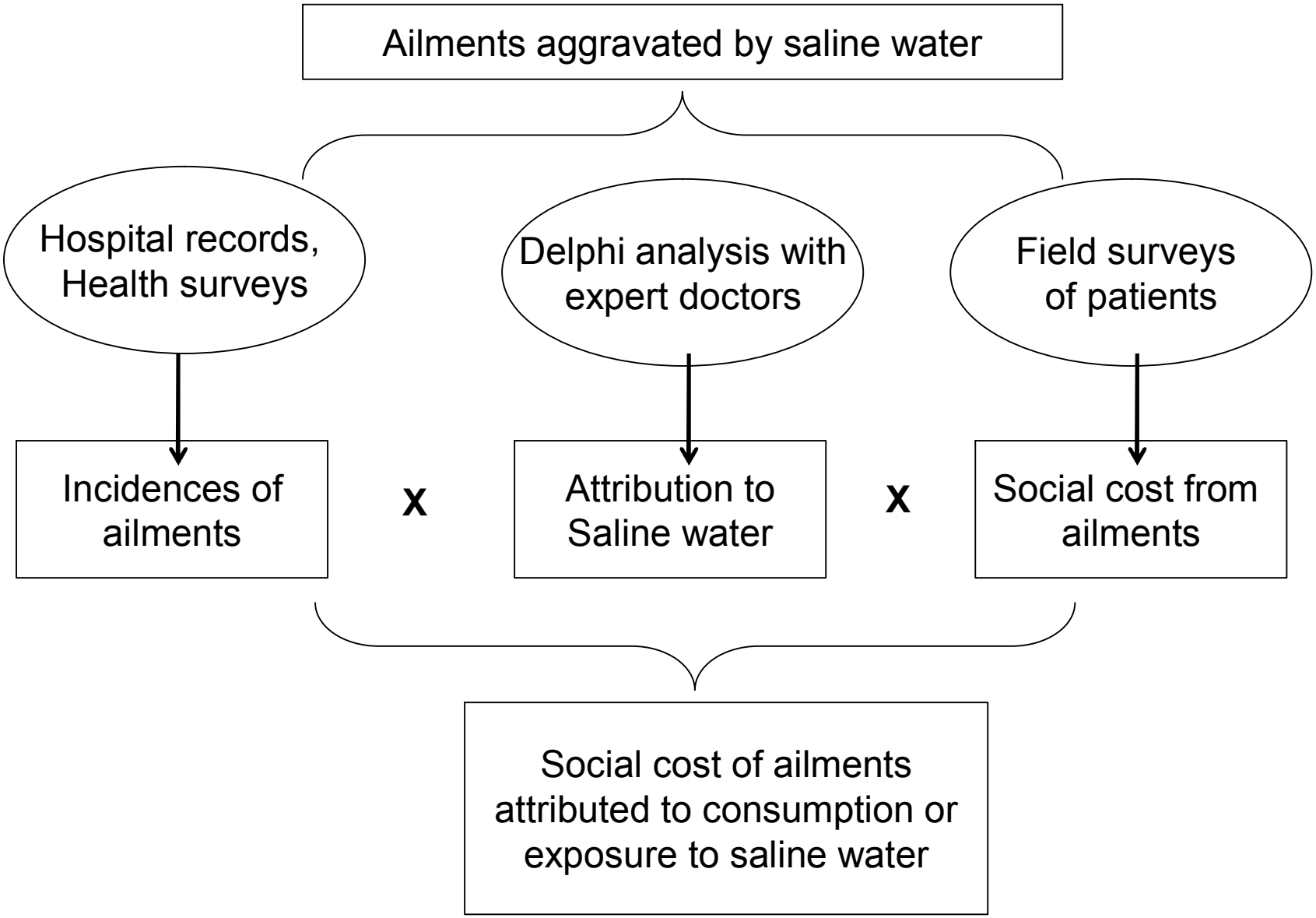
Eye

Hypertension

Hair Loss and dandruff

We are studying the first 3 ailments only

Methodology



Total costs due to Kidney stones

In salinity affected villages,

- **Medical costs = Rs. 5790 per person per year**
- **Wage loss costs = Rs. 2690 per person per year**
- **Drinking water costs = Rs. 750 per household per year**

Social costs due to Kidney stones form a significant part of income

Key Methodological Challenges

Extant of contamination

Health Impact of Contamination on Population

Incidences of Health Impact

Social Cost Due to Health Impact

Attribution of Health Problem to Water Quality

Outlines of Methodology for nationwide picture

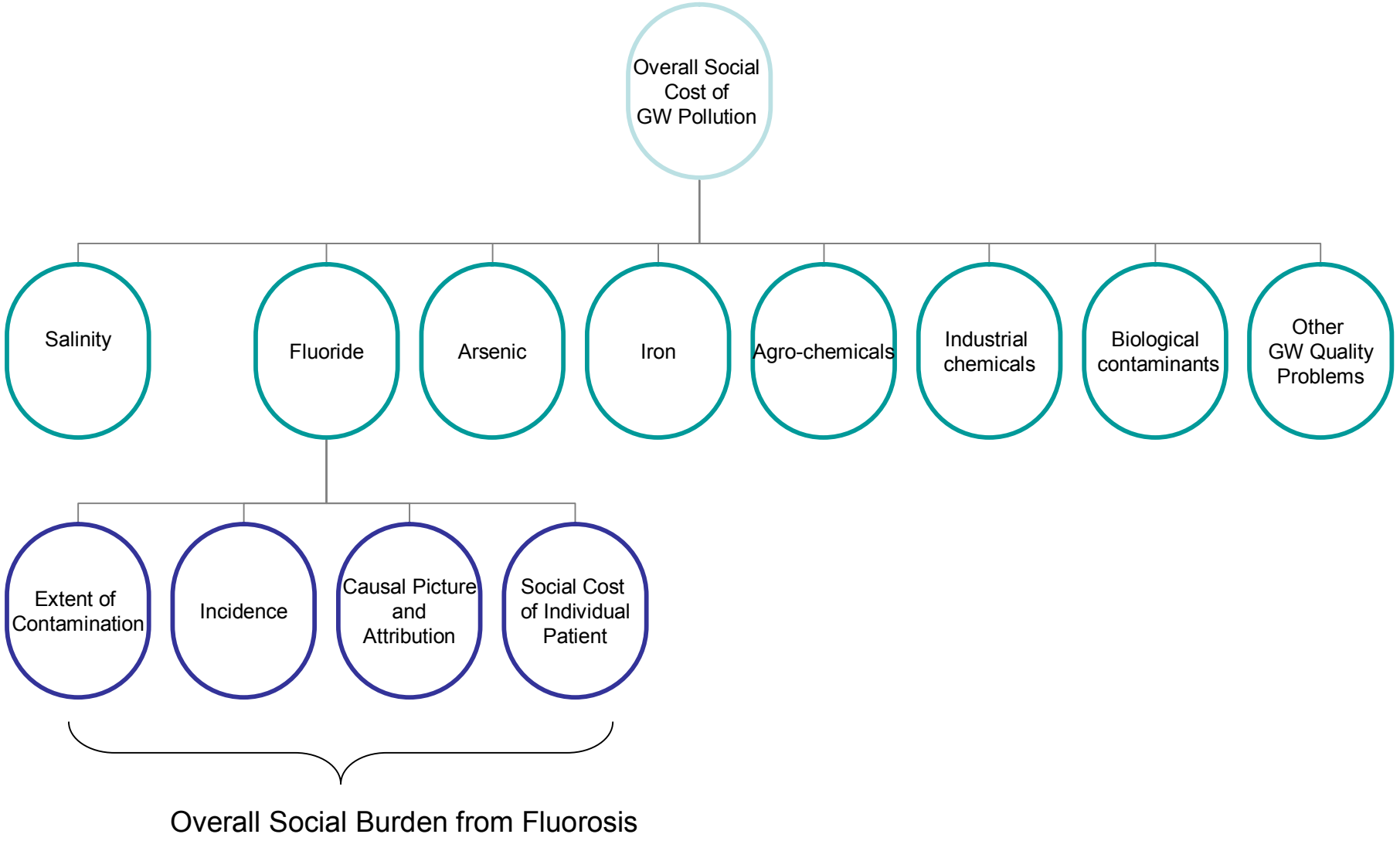
Construct Causal Picture of Water quality related Health Problems

Identify Attribution and Incidences

Estimate extant of Contamination

Sample Studies on Social Costs

Outlines of Methodology for nationwide picture



How does this total Social Burden Compare with our Total Investment for Mitigation?

Major Holes to Fill and Directions for Future

Accurate Picture of Groundwater contamination

Understanding of geochemical processes

Seeding Interest in Public Health agencies

Action Points for Mitigation

- Process driven Aquifer clean up

- Reducing Pollution Load

- Providing drinking water services

- Preventive Health , Early Diagnosis and Nutritive measures

- Diverting Social cost to end product

- Harnessing Rural Health Insurance for Preventive health measures eg. nutrition

In summary

- Major Health Burden of Water Quality Problems
- But our national databases are weak
- Linkages of contamination to health problems are not well identified
- Cost of prevention is less than social cost of impacts
- Methodological Issues need to be sorted out