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INCREASING GROUND WATER DEPENDENCY AND DECLINING WATER QUALITY IN URBAN WATER SUPPLY - A COMPARATIVE ANALYSIS OF FOUR SOUTH INDIAN CITIES

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INCREASING GROUNDWATER DEPENDENCY AND DECLINING WATER QUALITY IN URBAN WATER SUPPLY - A COMPARATIVE ANALYSIS OF FOUR SOUTH INDIAN CITIES[1]

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Abstract

This paper examines the extent of groundwater dependency and quality status in Hubli, Dharwad, Belgaum and Kolar cities in the context of National Water Policy. Household survey indicated dependency of 30, 51, 37 and 100 percent while the quality analysis indicated 45, 42, 22 and 97 percent as non-potable in the above cities respectively. Water markets captured a turnover of Rs. 50 crore in Hubli, Dharwad and Belgaum whereas in Bagepalli taluk, Kolar district alone, was Rs. 120 million/annum.

Introduction

The importance of groundwater for the existence of human society cannot be overemphasised. Groundwater is the major source for drinking, agricultural and industrial use. As the demand for water has increased over the years, providing safe and quality drinking water on a sustainable basis has been a tough mission to the authorities. Common problems prevail in larger cities while smaller cities are moving towards similar trends. The Ministry of Water Resources (MWR) has estimated that the demand for water in the top 35 cities is expected to double as the population of these cities would shoot up from 107 million (2001) to 202 million in 2021 (CSH Occasional Paper, 2002). Widespread water shortage problems have resulted in increased dependency on groundwater with tapping the resources to unsustainable levels.

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[1] The paper is based on two larger studies supported by the International Water Management Institute – Tata Program (for Kolar city) and Karnataka Urban Infrastructure Development and Finance Corporation (for Hubli, Dharwad and Belgaum cities). Both these studies were carried out by the Centre for Ecological Economics and Natural Resources, Institute for Social and Economic Change, Bangalore, India.

Groundwater is an important and integral part of the hydrological cycle and its availability depends on the rainfall and recharge conditions. Water utilisation projection for the year 2000, put the groundwater usage around 50 per cent in India and 80 per cent of rural water supply for domestic use. India's crisis faced in both rural and urban areas has been caused mainly due to improper management of water resources. There has been lack of adequate attention to water conservation, efficiency in water use, water re-use, groundwater recharge, and ecosystem sustainability. In Karnataka, out of 208 urban local bodies that come under Karnataka Urban Water Supply and Drainage Board, 41 depend on groundwater. Groundwater crisis, largely the result of human actions, like for instance, uncontrolled use of the borewell technology at high rate where often recharge is insufficient. During the past two decades, the water level in several parts of the country has been falling rapidly due to increased exploitation. For example, in Karnataka, 34 taluks are considered as 'critical' due to overexploitation. Intense competition among users - agriculture, industry, and domestic sectors is driving down the groundwater table drastically.

The situation is aggravated by the problem of pollution or contamination. Aquifer pollution from both point and nonpoint sources is becoming extensive worldwide. Nearly 45 million people around the world are affected by water pollution marked by excess fluoride, arsenic, iron, or the ingress of salt water (State of Environment Report, Karnataka, 2003).

In the Gediz basin of Anatolia, Turkey, nonpoint pollutants mostly agrochemicals, have polluted the groundwater (Shah et al 2000). In Argentina, Australia, Bangladesh, Chile, China, Hungary, India, Mexico, Peru and the United States of America, arsenic in groundwater has been detected at concentration greater than the Guideline Value, 0.01 mg/L or the prevailing national standard. According to British Geological Survey,

in 1998 of shallow tube-wells in 61 districts of Bangladesh, 73 per cent of the samples were above prescribed limit (World Health Organisation, 2001). Environment Protection Agency of The United States of America has estimated that roughly 13 million of the population of USA, mostly in the western states, are exposed to arsenic in drinking- water at 0.01 mg/ L. (http://www.who.int/mediacentre/factsheets/fs210/en/index.html).

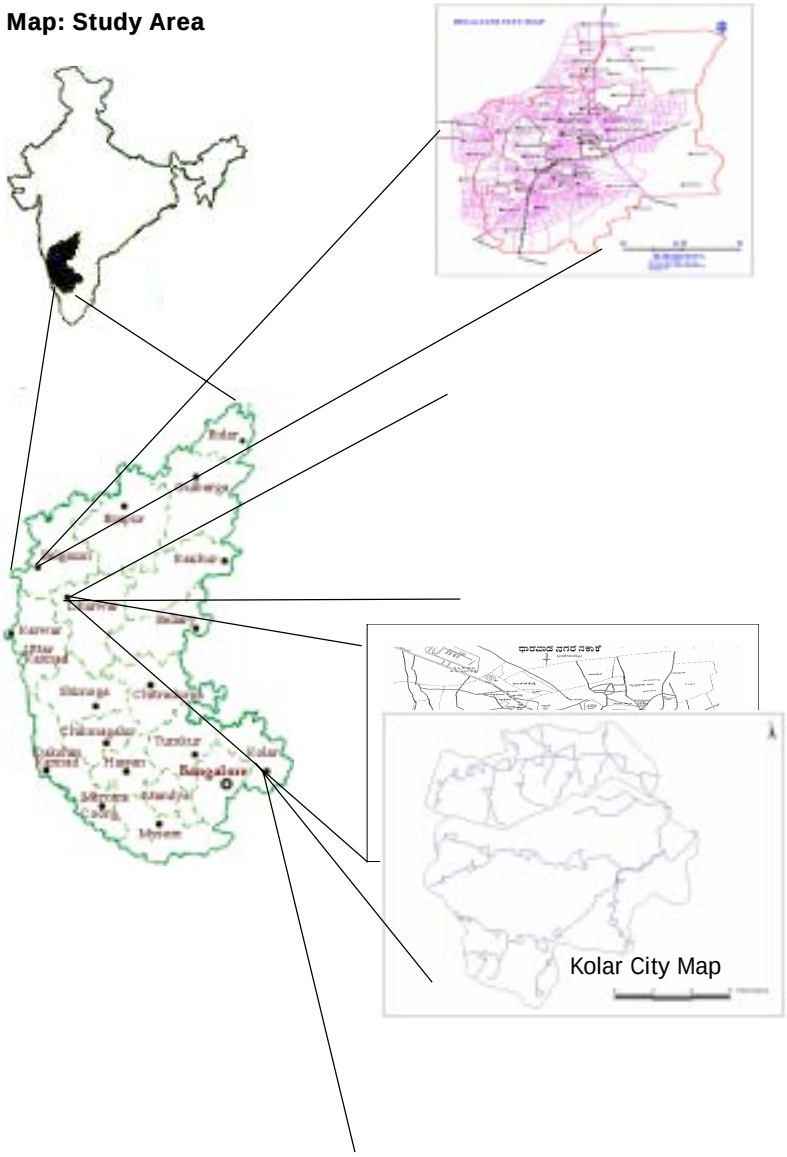
A survey by Central Pollution Control Board of India in 1995 identified 22 sites in 16 states of India as critical for groundwater pollution, the primary cause being industrial effluents. A recent survey undertaken by the Centre for Science and Environment from eight places in Gujarat, Andhra Pradesh and Haryana reported traces of heavy metals such as lead, cadmium, zinc and mercury. Excessive withdrawal from coastal aquifers has led to induced pollution in the form of seawater intrusion in Kachchh, Saurashtra, Chennai and Calicut. Waterborne diseases constituted 80 per cent of the health problems in India. Mandays lost due to such easily preventable disease are estimated to be around 73 millions (Wishwakarma, 1993) and water-borne diseases are the causes of nearly 15 lakh deaths in India annually (Deccan Herald, Jan 26, 1992).

Safe drinking water and sanitation facilities provided although not 100 per cent in the country is reported to have considerably brought down the incidence of diseases such as cholera, typhoid, dysentry and diarrhoea (Wishwakarma, 1993). Diarrhoea remains one of the commonest illness of children and also a leading cause of childhood mortality in developing countries. It is estimated that over 1,000 million episodes and 3 million deaths occur each year among children of less than five years of age in the developing countries (Bern et al., 1992, WHO). Many of these children die due to dehydration, dysentery and malnutrition. Diarrhoeal disease also represents an economic burden since children with diarrhoea admitted to hospital are often treated with expensive intravenous fluids and ineffective drugs, despite simple and effective treatment measures are available (WHO, 1992).

All the above-mentioned instances bring to the forefront the increasing levels of groundwater contamination. What seems relevant in the given context is to understand the status of groundwater quality and take adequate steps to rectify the problem. In this context, various institutional mechanisms have been evolved in different parts of the country and efforts taken to tackle the situation. However, most of the problems are attended to only when these problems are acute and brought to the limelight during critical situations. It is important to know these instances periodically to facilitate better decision making to act upon the situation. In this backdrop, this study was taken up in Hubli, Dharwad, Belgaum and Kolar[2] (for details on study area, see, Annex 1) focusing mainly on understanding the groundwater situation - draft and quality. The paper is divided into four sections. First section gives a picture about the groundwater dependency in all the four cities. Second section addresses the impact of extraction on the quality issues and its status in the respective cities while the third section specifies the emerging trends and issues; followed by conclusion in the fourth section.

[2] Hubli, Dharwad and Belgaum known for scarcity and unreliable water supply for more than three decades and Kolar facing severe scarcity and contamination were identified for the study. The Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC), who funded the current study, assist the urban agencies in the state in planning, financing and providing expertise to develop urban infrastructure. One of the aims is to provide adequate and safe water and proper sanitation to all the urban areas. KUIDFC intends to take up the 24/7 water supply in Hubli, Dharwad and Belgaum and also would like to understand the situation and trends before implementing the scheme. Whereas Kolar, funded by IWMI was chosen to understand the extent of contamination ward wise so that better decisions could be taken to address the crisis. Kolar Municipal Corporation also aided in funding the sample analysis.

Map: Study Area



Source: www.mapsofindia.com

Increasing Dependency On Groundwater

Water supply for Hubli, Dharwad and Belgaum is a major issue that is often debated. Similar to any other city, urban population resultant of growing urbanization, is not new to these cities. However, the problem has existed for more than three decades and has become more acute in recent years. Water supply to Hubli, Dharwad and Belgaum cities is both from surface and groundwater unlike Kolar where it is completely dependent on groundwater as described in Table 1.1.

Table 1.1: Water Supply in study cities (in MLD)

Cities	Surface Water			Quantity of groundwater supplied	Total quantity of water supplied	Lpcd
	Sources	Quantity supplied	Actual quantity reaching the consumers			
Hubli	Malaprabha and Neersagar	64	26	9	35	66
Dharwad	Malaprabha	32	19	3	22	70
Belgaum	Rakkaskoppa and Hidkal	47.25	19	1	29	71
Kolar	-	-	-	7	7	40

Source: Based on field survey

For Hubli and Dharwad, the bulk water supply is drawn from the Malaprabha and Neerasagara reservoirs. Responsibilities were divided between two agencies, where Karnataka Urban Water Supply and Drainage Board (KUWSDB) was responsible for bulk supply and maintenance of water supply systems and Hubli Dharwad Municipal Corporation (HDMC) was responsible for operations and maintenance and supplied water up to the consumer point. This led to the interdependence, co-ordination problems and conflicts between agencies during execution of work. It was difficult to see any of the agencies having an overview, rather each agency blamed the other for inefficiency. Although efforts were made to resolve, the effect seems to be minimal. Implications of problems in one

agency will trigger the problem in another. For example – HDMC was tied up in spending; according to the KMC Act of 1976, it cannot do any execution work beyond 50 lakhs. So, they cannot attend to major repairs and were dependent on KUWSDB. Another major problem faced by HDMC was high volume of unaccounted for water, which drastically curtailed the supply till 2002. Though 64 MLD of surface water was drawn, the actual quantity supplied is 26 MLD in Hubli and 19 MLD in Dharwad excluding 40 per cent of unaccounted for water. Hence, it was considered important to have a single institutional set up and currently KUWSDB is responsible for the management of water completely. As KUWSDB focuses only on water management, it has organised its work in a professional way in addressing the issues of water. The problems are being addressed and being resolved in a phased manner by various interventions. Although small, the interventions in the arena of water management by the KUWSDB have been significantly positive. For example: reduction in leakages by installing 25 mm air valves at joints at a regular interval of 200 meters helped in releasing the air, thus avoiding leakages. Such interventions were made at 40 locations. This has not only avoided leakages, but has improved water supply and helped in reducing the avoidable burden on the engineers who otherwise would have to rush to leakage spots to rectify the problems. This has helped in equitable distribution amongst the households and also in saving water.

Apart from the surface water source, the KUWSDB is supplying groundwater by maintaining 1,200 borewells in Hubli and 495 in Dharwad. The total volume of water supplied by the agency is 35 MLD in Hubli and 22 MLD in Dharwad with the per capita supply of 66 and 70 lpcd respectively which is far below the requirement recommended by the State Water Policy 2002 of 135 lpcd for City Corporation areas.

However, in Belgaum, the responsibility is still between KUWSDB and City Municipal Corporation, in which the former is involved in bulk supply from the sources and the latter is responsible for distributing the water to the consumer. The city is served by Rakaskoppa and Hidkal

reservoirs with the supply of 54 MLD. The water is supplied once in 3 to 4 days and varies across wards. During summer crisis, frequency of supply is once in 10 days. Duration of water supply ranges between 2 and 4 hours usually. The Corporation also adopts to supply water through tankers during crisis since the last few years.

In Kolar, the City Municipal Council is the sole organization responsible for water supply. Due to improper and erratic rainfall, the surface supplies (tanks) have dried up and presently groundwater is the only source, which is contaminated with high Nitrate and Fluoride. People rely on alternative sources like purchase of water from tankers, neighbour households or drill own borewells.

Irrespective of speaking on the constraints in supplying adequate surface water, the City Municipal Corporation is left with no choice than relying on groundwater. Apart from this, people have made huge investments to have their own source by drilling borewells and open wells. In all the newly upcoming areas, drilling borewells is a common feature. The detail on number of wells across cities has been given in Table 1.2.

Table 1.2: Estimated Number of Borewells

Sectors	Hubli	Dharwad	Belgaum	Kolar
Households	5,900	2,050	12,137	200*
CMC owned wells	1,200	501	1,663	119
Commercial establishments	1,867	165	700	-
Total	8,967	2,716	14,500	319

* Inclusive of both households and commercial establishments

Source: Based upon field survey

The groundwater consumption by various sectors has been given in Table 1.3. The dependency on groundwater is 51 per cent in Hubli, 30 per cent in Dharwad, 37 per cent in Belgaum and Kolar entirely depends

on groundwater. It can be seen from the table that HDMC has tapped its resources from groundwater to meet the increasing demand unlike Belgaum where commercial establishments dominate.

Table 1.3: Water Utilization Across Cities (in MLD)

Key users	Total water consumption		
	Hubli	Dharwad	Belgaum
Households	4.25	1.34	1.32
CMC supply	9.00	3.04	1.00
Commercial establishments	4.12	1.01	16.73
Tankers	1.75	0.52	0.81
Total groundwater draft	19.0 (30)	(51) 20.0	6.0 (37)

Note: Figures in parenthesis indicates dependency in percentage

Source: Based on field survey

It was observed that in Hubli and Dharwad, large quantities of surface water drawn have failed to meet the increasing demand. Problems encountered have been poor service delivery, low charges, financial constraints, technical inefficiencies, management problems etc, that has formed into a vicious cycle.

However, the core of Belgaum city is completely dependent on groundwater through open wells as availability of water is plenty and these wells were dug much before the surface water supplies. With the expansion of the city and inadequate surface water supplies, the peripheral areas have resorted to drilling bore wells. Apart from this, the peripheral areas do not have groundwater in abundance compared to the core of the city.

As said earlier, Kolar, unlike the three cities mentioned above, is completely dependent on groundwater. Earlier, the city corporation supplied water through the tank (Ammanni Kere), which has completely

dried up currently due to inadequate and poor rainfall. Heavy dependency on groundwater has led to severe contamination of water as the borewells are being drilled to depths up to 1,000 feet.

With intense dependency on groundwater, depletion is evident over time. A study conducted by the Department of Mines and Geology (DMG) in Hubli and Dharwad during 2000 to 2004 indicated that depletion was evident as water level had declined from 3.42 M to 47 M in Hubli and 3.31M to 35.14 M in Dharwad respectively. Geologists have highlighted the fact that continuous drought, poor rainfall, excessive drilling of borewells as the causes for depletion. The bore well drillers also support this view. The private water tankers have also added to the problem in certain areas. Increased tanker business with high extraction levels has aggravated depletion, for instance, in Keshwapur in Hubli where the highest number of tankers are found, the water table level has gone to 800 Ft. Similarly, in Kolar, the situation is more serious. Groundwater report on Karnataka, brought out by the DMG, 2004, says that the whole of Kolar is an overexploited zone falling in the 'Dark zone' category (Down to Earth, September 8, 2005). In Belgaum, the situation is not different. Between 1991-92 and 2004-05, the water table across the Belgaum district had declined by 5 to 300 M due to overexploitation. The 1991-92 figures show that the depletion of the water table was between 2 and 5 M in respect of open wells and 50 and 100 M in terms of borewells. These figures changed during 2004-05 when the depletion of the watertable in respect of open wells was between 9 and 24 M and 90 and 300 M in terms of borewells (The Hindu, June 11, 2005).

Although the City Municipal Corporations highlight rainwater harvesting as a better alternative, nothing significant has been done to promote it nor concerted efforts has been undertaken although the National Water Policy 2002 emphasises this. A comparison of the status in view of the designed policy and actual situation are revealed in Tables 1.4 and 1.5 with respect to conservation of water and groundwater development.

Table 1.4: Provisions for Conservation of Water in National Water Policy 2002

Specifics	Hubli	Dharwad	Belgaum	Kolar
Optimized efficiency utilization				
Awareness creation	Awareness creation prevalent	Awareness creation prevalent	Awareness creation prevalent	Awareness creation prevalent
Regulation	Yes, but not practised	Yes, but not practised	Yes, but not practised	Regulation is initiated as a policy but practised in certain parts strictly
Incentives and disincentives	No	No	No	No
Resource conservation and augmentation	Minimizing losses in the conveyance system and rehabilitation of existing systems	Minimizing losses in the conveyance system and rehabilitation of existing systems	Minimizing losses in the conveyance system and rehabilitation of existing systems	Partially prevalent
Performance Improvement	Working on certain aspects	Working on certain aspects	Working on certain aspects	Working on certain aspects
Maintenance and modernization of structures and systems	Working on certain aspects	Working on certain aspects	Working on certain aspects	Working on certain aspects

Source: Based on field survey

Table 1.4 explains the limited efforts undertaken by the cities with respect to conservation in comparison to the designed policy. In spite of all these awareness creation efforts is at the infant stages; no specific ways are prevalent specifying incentives or disincentives. Conservation is limited to minimizing wastage through technical repairs only. Performance improvement and modernization of structures and systems have been covered on certain aspects only.

Table 1.5: Provision for Groundwater Development in National Water Policy 2002

Details	Hubli	Dharwad	Belgaum	Kolar
Periodical reassessment of groundwater potential	Reassessment is done with observation wells	Reassessment is done with observation wells	Reassessment is done with observation wells[3]	Reassessment is done with observation wells
Regulation of groundwater resource exploitation	No	No	No	Yes
Prevention of environmental consequences of over extraction by the Central and State governments	No	No	No	No
Development and implementation of water recharge projects	No	No	No	No
Integrated and coordinated development of surface and groundwater resources	No	No	No	No

Source: a. National Water Policy, 2002
b. Based on field survey

The Department of Mines and Geology, Government of Karnataka does periodical assessment of groundwater indicating warning bells to avoid depletion. The other important areas of regulation, development of recharge projects; prevention of environmental consequences and integrated water resource management exists in limited ways, thus painting a bleak picture of groundwater management.

[3] Neglected open wells built during the British times were rejuvenated, 9 wells serve 20,000 households and a population of around 1 lakh.

Water Quality Status

Water quality refers to the physico-chemical[4] and biological characteristics of water that will influence its suitability for a specific use. The concentration of ions depends on various factors such as geological formations and soil types of the basin area, equilibrium conditions of the solutes, and absorption by clay particles in suspension and biological processes. Water to be used for drinking purpose should be free from colour, turbidity, odour and microorganisms. Chemically, the water should preferably be soft, low in dissolved solids, and free from poisonous constituents. Pollution of groundwater resources has become a major problem and pollution of air, water, and land has an effect on the contamination of groundwater. Besides, discharge of untreated wastewater and leachate from unscientific disposal of agriculture, industrial and municipal solid wastes also add on.

Several studies done over different points of time on groundwater quality have indicated contamination in Hubli and Dharwad. A study by Hegde and Puranik (1990, and 1992) has highlighted the hardness of groundwater and high concentration of lead and cadmium. High concentration of Ca and Na was noticed in open wells and borewells of the Hubli area which may be attributed to the cation exchange exhibited by clay minerals and also sewage contamination (Hegde, *et al*, 1992). Another study by Hegde and Puranik (1999) has reveled that, groundwater in Hubli city is polluted by nitrate. The intensity of the pollution was more in old city blocks, market areas, low lying localities and even in thickly polluted areas. The pollution was also noticed in the wells existing adjacent to sewage courses. Hegde and Togalmath (1999) in their study at Hubli have highlighted concentration of Ca, Mg, Na+ and K are relatively high in the older areas than the other areas.

[4] The physical properties of water include – colour, turbidity, taste, temperature, pH and electrical conductivity. The chemical constituents include – mineral ions, gases, organic matter, Cations (sodium, potassium, calcium and magnesium ions) and Anions (chlorides, sulphates, bicarbonate and nitrate ions).

In Kolar, more than 80 per cent of the children in the age group of 6-14 suffer from skeletal and acute dental fluorosis due to excess fluoride. Epidemiological survey has revealed that over 26,000 people suffer from dental and skeletal fluorosis and more than 39,000 people are prone to it. The fluoride concentration in groundwater of Kolar ranges from 2.8 to 4.3 mg/L, which is far above the permissible limits (The Times of India, 06 June 2002).

A study on the chemical characteristics of groundwater in Malaprabha sub-basin of Belgaum District has indicated that the quality of groundwater in the downstream region exceeds the acceptable limits for various parameters due to excessive irrigation by excess application of fertilizers and pesticides (Varadarajan and Purandara 2003). In another study, groundwater has shown high concentrations of sodium, potassium and nitrate, which has been attributed to sewage water pollution and fertilizers, and also high concentration of total hardness (Hanamgond, 2000). The total dissolved chemicals in groundwater of Belgaum, Dharwad and Gulburga have exceeded 5,000 mg/l rendering the groundwater non-potable and also unsuitable for irrigation. Also, in districts such as Kolar, Chitradurga, Tumkur, Bellary, Raichur, Gulbarga, and Bijapur, groundwater at deeper levels is contaminated with fluoride varying 6 to 13 ppm (Chandrashekhar, 2002).

In all the cities, detailed survey was carried out for 6430 households through structured questionnaires. Seven hundred and fifty six representative water samples were collected in all the cities to know the quality of groundwater. The samples were analyzed for the fifteen[5] drinking water parameters and results are indicated in Table 2.1

[5] Turbidity, Colour, PH, Electrical conductivity, Total Dissolved Solids, Chloride, Sulphate, Fluoride, Nitrate, Calcium, Magnesium, Sodium, Iron and Alkalinity and bacteriological parameter Most Probable Number (MPN).

Table 2.1: Water Quality Status

Cities	Number of samples analysed	Number of nonpotable samples	Total number of wards affected
Hubli	250	98 (39.2)	17[6]
Dharwad	200	90 (45)	16[7]
Belgaum	200	41 (20)	17[8]
Kolar	137	133 (97)	31 (All wards)

Note: Figures in parenthesis indicate percentages Source: Based upon field survey
Source: Based on field survey

In Hubli, 39 per cent of the samples analysed were non-potable, and it was 45 per cent in Dharwad, 22 per cent in Belgaum and 97 per cent in Kolar. In Hubli, quality was more contaminated in the core of the city[9]. The major contaminants were turbidity, hardness, total dissolved solids, sulphates, nitrate, calcium and coliforms in Hubli and Dharwad, whereas in Belgaum and Kolar, water was heavily contaminated with fluoride. In Kolar, the contamination was mainly due to the larger depths in the groundwater table and wastewater intrusion from households and industries. Specific details of the samples contaminated, city-wise have been explained in Table 2.2. The effects of contamination could be serious as indicated in Annexe 2.

[6] Ward No. 49 to 66

[7] Ward No.s 2-13, 15-18

[8] Ward No.s 19-29, 32, 37, 39, 40, 42, 45-46, 50, 52, 56-58

[9] (Wards – 49-61 and 63-66) compared to the outskirts (Wards – 24-40).

Table 2.2: Number of Samples Contaminated

Physico-chemical parameter	Desirable limits	Permissible limits	Number of samples		
			Dharwad	Hubli	Belgaum
Turbidity in NTU	5	10	17	15	19
Colour in Hazen units	5	25	0	0	1
PH	6.5 to 8.5	Not specified	0	0	0
Total Dissolved Solids mg/l	500	2000	31	23	1
Total Hardness (as CaCO3), mg/l	300	600	38	67	5
Chloride (as Cl), mg/l	250	1000	1	2	0
Sulphate (as SO4), mg/l	200	400	26	0	1
Fluoride (as F), mg/l	1.0	1.5	0	0	8
Nitrate (as NO3), mg/l	50	No relaxation	53	59	7
Calcium (as Ca), mg/l	75	200	26	51	0
Magnesium (as Mg), mg/l	30	150	0	0	0
Iron (as Fe), mg/l	0.3	1.0	1	0	0
Alkalinity, mg/l	200	600	1	0	0
MPN	0	10	19	6	0

Source: a. Department of Mines & Geology
b. Based on water quality analysis

Turbidity affected 9.3, 6.0 and 10.5 per cent of water in Dharwad, Hubli and Belgaum respectively. Total dissolved solids (TDS) consist mainly bicarbonates, carbonates, sulphate, chlorides and nitrates of calcium, magnesium, sodium and potassium. The concentration of TDS was severe in Kolar, Dharwad (18.3 per cent) and Hubli (9.2 per cent) whereas Belgaum is free from TDS contamination. In Kolar, the number of wards affected were 3-4, 7-10, 20-21, and 26-30. The High concentration could result in physiological disorders. People witnessed formation of scales, change in taste and colour.

Total hardness is another constituent that has affected the water quality in Dharwad, Hubli and Kolar cities. In Hubli and Dharwad the water was very hard (26.8 and 23.5 per cent respectively). Higher levels of hardness were seen in the core of the cities where groundwater extraction was high. In Kolar, the affected wards were 1-2, 4, 7-9, and 28-30. In addition to hardness, Kolar was heavily contaminated with fluoride affecting four wards viz: 16, 22, 25 and 31, where as in Belgaum, 4.5 per cent of the samples showed excess fluoride and is completely absent in Hubli and Dharwad. The reason could be attributed to the increased depth and overdraft, resulting in excess dissolution of fluoride into strata. In Belgaum, the peripheral areas had more bore wells with high fluoride content, as it layered with basaltic rock which favoured greater dissolution of fluoride containing minerals in underground surface.

Nitrate is one of the major pollutants in Hubli (23 per cent), Dharwad (36 per cent) and Kolar. The main sources include sewage drains and septic tanks. The number of affected wards in Dharwad were 5 – 13 and the number of wards contaminated were 3 and 6 in Kolar. Excess nitrate content in the water samples of well water could be due to seepage of sewage from the surrounding vicinity and dispersal of solid waste to the water. The contamination has seen in the centre of the cities where dependency on groundwater was high. Presence of coliform bacteria was seen in Hubli and Dharwad (9.5 per cent) in the range 11 to 1800 MPN/100ml, which indicates sewage contamination. The reason could be presence of septic tanks near these wells leading to sewage intrusion as all open tank samples showed contamination.

In Kolar, one or other parameters had exceeded its permissible limits in each ward. The most affected parameter was sodium, which was contaminated in 17 wards (55 per cent), bicarbonate 12 wards (39 per cent), chlorine and calcium had affected in 9 wards (30 per cent).

Based on the National Water Policy 2002 provisions on quality parameters, comparison was made with respect to the study cities in Table 2.3

Table 2.3: Provisions for Water Quality in National Water Policy 2002

Details	Hubli	Dharwad	Belgaum	Kolar
Improvements in existing strategies	Partially done	Partially done	Partially done	No
Innovation of new techniques to eliminate pollution	No	No	No	Yes
Regular monitoring of both surface and groundwater	Yes (for surface water)	Yes (for surface water)	Yes (for surface water)	No
Treatment of effluents before discharging into natural streams	No	No	No	No
"Polluter pays' principle for management of polluted water.	No	No	No	No
Legislation to prevent encroachment and deterioration of water quality	Law exists but imple-mentation is poor	Law exists but imple-mentation is poor	Law exists but imple-mentation is poor	Law exists but imple-mentation is poor

Source: a. National Water Policy, 2002
b. Based upon field survey

Efforts have been made towards improving existing strategies and Kolar has defluoridation plants. Surface water monitoring has been done in all the cities but not applicable to Kolar as they had no surface water supplies. None of the cities had provision for treatment of neither effluents nor any policy on charging the polluter, which certainly had aggravated the problem. Although laws were prevalent to address deterioration of water quality, implementation was poor in all the cities. The seriousness of the problem has already been discussed above, thus calling for immediate action.

Emerging Issues

Declining Quality

Among the four cities studied, Kolar faced serious impacts of fluoride and nitrate contamination throughout the city unlike in Hubli, Dharwad and Belgaum. People flocked to the hospitals with complaints of joint pain, tooth corrosion and fatigue. While the rich had the capacity to purchase mineral water, the poor were left with no choice. Recent studies by DMG, on water quality has indicated that water was highly contaminated with fluoride and nitrates and Kolar is classified under Dark Zone where utilisation quantity was more than 85 per cent. Depths have reached up to 1000 ft. There are intensive irrigation activities around the periphery (or conurbation boundary) of Kolar town. The land use/land cover pattern of Kolar town had changed tremendously over a period of time. The agricultural activities on the upstream side of the tanks had intensified and also the usage of modern farming techniques.

In Hubli, Dharwad and Belgaum, currently people are not experiencing the immediate need as no serious impacts have been noticed prominently. One of the reasons is that the groundwater is used only for usage and not for drinking and no quality testing is done to see the impacts of water on health by any particular agency, hence, nothing supports the health ailments to water.

Flourishing Water Markets

Packaged drinking water has captured a large market relatively over the years. Demand for packaged drinking water has been definitely on the increase as opined by the packaged water distributors of Hubli, Dharwad and Belgaum. Irrespective of the company the sales go up during summer for all companies while it dips during rainy and winter seasons. Tankers constitute another important actor in the trade. Around 100 tankers thrive in the cities. The market is also characterized by some malfunctioning

related to lack of regulation and control, while the companies are not registered, regulations on quality control are nil. Kolar also thrives on the same lines.

Table 3.1: Growing Water Markets

Cities	Packaged drinking water		Water supplied through tankers in MLD	
	Quantity of water sold in MLD per annum	Turnover in Crores per annum	Off season	Peak season
Hubli	3.28	2.4	1.75	7.26
Dharwad	0.21	1.0	0.52	4.37
Belgaum	2.4	3.0	2.52	4.2
Kolar	-	-	0.135	-

Source: Based on field survey

Higher the water scarcity, higher will be the business for borewell drilling companies. All over the state, a large number of borewell drilling companies have been established in recent years. Sadly, none of the borewell drilling companies is made accountable on the number of borewells drilled, the extent of drilling or any rules. However, the city corporation makes it compulsory for any customer to take the permission before drilling a borewell which is an appreciative effort taken to regulate these borewell companies in study cities but not religiously followed. Migratory drilliers, mostly from Tamil Nadu make roaring business as they drill for less cost comparatively.

Bagepalli taluk in a low rainfall area of Kolar district has some 20 agencies dealing with borewells. 20 borewell agencies together garner Rs.2.1 million annually. Bagepalli taluk spends Rs.120.25 million annually just on drilling borewells. One of the major reason for this booming business is high rate of failure, which is up to 60 per cent, up from 30-40 per cent a few years ago. Declining groundwater and high failure rate

helps local business, though it deprives farmer's kitty. Increasingly farmers are borrowing funds for wells and a few of them resort to suicides, we were told, when debt mounts up beyond their capacity (Raju, 2004). In Hubli, Dharwad and Belgaum, situation is not as worse. The annual average turnover is up to 5.5 lakhs in Hubli and Dharwad put together. Although all the drilling companies mentioned that their profits ranged between Rs. 2,000 and 5,000 per well, it is important to understand the actual profits derived.

Unreliable Water Supply

Water supply from the authorities has been poorly managed with inefficiencies in frequency, duration and quantity. Public are left with little choice and hence, depend on own sources through drilling borewells. However, open wells are still prevalent in some of the areas, which are in use even to this day. Instances where people have made their own arrangements in managing water, thus group wells are commonly found. In short, people have made their own institutional arrangements in terms of rules, regulations and sharing finances to procure water. While the high-income groups have invested more in such situations, low-income groups have invested on storage gadgets. Interestingly, people did not complain of shortage of water, probably, people had got used to the fact of storing water and the frequency of water supply was better comparatively, which meant a lot of relief. In Hubli, Dharwad and Belgaum, people were not keen to have 24 hours of supply throughout the week as they were not willing to bear the charges, which would also be hiked in comparison to the low charges they are paying currently. People who had set up their own system did not feel the need for it. However, there were some people who did mention that, they had no choice and adapted to the prevalent system. Comparing the standards as prescribed in the National Water Policy 2002 with the cities, the status has been shown in Table 3.2

Table 3.2: Provisions for Drinking Water in National Water Policy 2002

Details	Hubli	Dharwad	Belgaum	Kolar
Providing adequate and safe drinking water facilities to the entire urban and rural population	Safe drinking water is provided but inadequate	Safe drinking water is provided but inadequate	Safe drinking water is provided but inadequate	Safe drinking water is provided but inadequate and limited
Irrigation and multipurpose projects to include a drinking water component when no other source is there	Yes	Yes	Yes	Not applicable
Emphasis on financial and physical sustainability	Attempts are being made	Attempts are made	Yet to be done	Yet to be done
Participatory approach to water resources management	No	No	No	No
Private sector participation should be encouraged	No	No	No	No

Source: a. National Water Policy, 2002

b. Based on field survey

Management Issues - Poor Co-ordination Between Departments

In Hubli and Dharwad water management was managed by two agencies. This led to interdependence, co-ordination problems and conflicts among the agencies during execution of work. New areas were given permission for development without providing adequate infrastructure. In short, there is no co-ordination between departments. This led to various implications

in terms of wasted investments by both public and private agencies. While the finances were dealt by the State, the bulk supply by the KUWSDB, and the operation and maintenance were by the HDMC. It was difficult to see any one of the agencies having an overview. Rather each agency blamed the other for inefficiency and is a cause for ineffectiveness in working. Although efforts are made to resolve at times, the impact seemed to be minimal. Implications of problems in one agency had triggered the problem in another. With the handling over of both bulk supply and distribution to the consumer point the KUWSDB, it will be interesting to see positive changes. However, in Belgaum, there seemed to be conflict among the agencies in shifting responsibilities to a single agency and was getting postponed. In Kolar, although a single agency was dealing with water management, they had serious issues that need to be resolved - poor database, shortage of staff, overworked existing staff, negligence of technical matters, and poor revenue collection.

Technical Inefficiencies

Technical inefficiencies were encountered at various points and levels. Quality of system executed does not meet the standards. Proper precautions were not taken at various stages. Although some of the problems could not be solved, a majority of them could be solved, for instance, the original capacity to lift water was 150 MLD, where as the pumping capacity is only to the extent of 100 MLD while the rest was lost in leakage. Filtered and chlorinated water was wasted and used in agricultural lands. Presently, worn out machinery triggered fresh investments to function well. Leakage (unaccounted for water) was a problem right from the beginning of inception of the project. Though huge investments were made to draw surface water from long distances, leakages were obviously leading to huge quantities of wastage. This, in turn, does not serve the purpose in terms of service or usage. Little care was taken to rectify small repairs with respect to taps by the department. Poor network further caused distributional problems, inequitable distribution and aided illegal connections. It became difficult to supply

water everyday particularly because the network was old and to make it feasible lot of supporting staff and finances were required. Added to all this, lack of skilled staff in handling technical problem aggravated the situation. On the other hand people's callous attitude when water was supplied prove that water was mismanaged.

Absence of Sewage Treatment Facilities

Hubli, Dharwad and Belgaum have partial underground drainage (UGD) system to dispose domestic wastewater. UGD covers about 65 per cent in Hubli, 25 per cent in Dharwad, and 60 per cent in Belgaum. Peripheral areas and revenue pockets within the CMC limit have no sewerage facilities. They largely depend on individual septic tanks for their domestic wastewater disposal. In Hubli, the network covers part of south, west and central area. In Dharwad, only the central area is sewered (9 -12 wards). As these cities are not served by sewage treatment plants, the untreated wastewater is being discharged into natural water bodies, tanks and lakes. The toilets of individual houses are connected to septic tanks with soak pits. The soak pits are not so effective in dispersion of effluent to subsurface and hence, the overflow of wastewater from septic tanks into storm water drain is a common phenomenon. Sewage flowing in storm water drains and open lands poses environmental problems like contamination of water bodies and groundwater sources apart from poor aesthetics, foul smell and related water borne diseases. In Hubli, few farmers pump raw sewage for irrigation. The implications on health of the farmers, on agriculture have not been addressed.

Poor Public Awareness

Capturing from people's perspectives on water management, it is still seen as the responsibility of the government as people lack a sense of belonging. Irrespective of facing scarcity of water, people tend to waste water on the days of supply (water is supplied once in five days). The habit of spilling away all the stored water is prominently noticed as people have a tendency or psychological satisfaction of storing fresh water. Taps

are not closed properly after usage both at the households as well as public stand posts. With no meters working, although installed, people tend to waste water as they pay flat charges.

Lately, several initiatives are being undertaken by KUWSDB to create awareness (Hubli and Dharwad) among the public about the efficient use of water. Clear and informative charts have been displayed in the KUWSDB office. The brochures have been printed in the local language for easy understanding. The posters highlight the action to be taken seriously with respect to illegal connections, immediate payment of arrears, last date to pay water bills, water meters to be checked and reinstalled and co-operative efforts for water management. Payment charges for household connections and commercial connections, price variations, new connections, repair costs for specific activities and related details have been pasted on walls making it clear and easy for communication. There are brochures given for easy understanding if consumers require them. Announcements by auto about paying water charges and legalising illegal connections were made. Awareness creation programmes were conducted at Hubli about conserving ground water and promoting rainwater harvesting.

WHO Guidelines

WHO advises national and local drinking water regulators, enterprises and organizations around the world about the challenge of providing safe drinking water. WHO's updated Guidelines for Drinking-water Quality (GDWQ) will help regulators and water service providers the world over to maintain and improve the quality of their drinking water. An attempt has been made to address the status of the study cities in view of the guidelines specified as explained in Table 3.3.

Table 3.3: Provisions for Drinking Water in the National Water Policy 2002

WHO Standards	Hubli	Dharwad	Belgaum	Kolar
Control of Microbial contamination	Yes	Yes	Yes	Yes
Control of disinfections	Yes	Yes	Yes	Yes
Monitoring	Monitoring for small sample size	Monitoring	Monitoring	Yes
Remedial action for chemical contaminants	No[10]	No[10]	No[10]	Partial
Health risk due to naturally occurring radionuclides should be considered	Not applicable	Not applicable	Not applicable	Not applicable
Conducting investigation if a majority of the community complains on taste, odour or appearance	Yes	Yes	Yes	Yes
Integrated management approach collaborating all relevant agencies	No	No	No	No
Surveillance through continuous public health assessment Review of safety and acceptability of drinking water supplies	No	No	No	No
Four areas of focus to protect public health through				
a) Surveillance of health status and trends	No	No	No	No
b) Establishment of norms and standards	Yes	Yes	Yes	Yes
c) Representing health concerns in wider policy development	Yes	Yes	Yes	Yes
d) Direct action through subsidiary bodies or guidance through local entities	No	No	No	No
Management of catchments inspection and authorization of activities, verifying and auditing.	Yes (only for surface water)	Yes	Yes	Not applicable
Specific guidance to communities/ individuals in designing and implementing	No	No	No	No
Quality assurance and control	Yes	Yes	Yes	Partial
Implementation of water safety plans	No	No	No	No
Active involvement of communities for effective and sustainable programmes	No	No	No	No
Surveillance programmes through education programmes	No	No	No	No
Providing guidance to consumers to avoid technical inefficiencies and contamination at households through education programmes	No	No	No	No

Source: a. WHO Guidelines, 2004
b. Based on field survey

[10] Samples indicated nitrate and hardness of water quality, however since people do not consume groundwater in Hubli and Dharwad health effects were not observed.

It can be observed from the above table that efforts towards controlling microbial contamination, disinfections and responding to public during crisis was prevalent in all the cities. Some efforts in monitoring were indicated but insignificant as it covered small sample size. Remedial actions towards chemical contaminants were not addressed in these cities. For instance, as Kolar is facing serious health impacts of Fluoride and Nitrate contamination like joint pain, tooth corrosion and fatigue, no proper treatment had been adopted for supplied water except the application of bleaching powder without any guidelines. No proper training has been provided to the worker who operates the De-fluoridation plant. However, in Hubli, Dharwad and Belgaum, currently people are not experiencing the serious impact, as the groundwater is not used for drinking purpose. It is important to analyse water quality frequently and to study the impact on health by concerned agencies.

The system was blatantly weak on integrated management approach involving all relevant agencies, communities and individuals in designing and implementing; public health assessment and implementing water safety plans. Awareness creation and guidance to consumers is still in the infant stage. Unless all the dimensions are covered simultaneously, results would remain feeble.

Conclusion

The Government and the public have invested heavily on creating and maintaining of assets for tapping groundwater mainly because of the unreliable and inadequate water supply. It is not only the capital cost but also more so the recurring O&M besides the coping costs. The public has been forced to look for alternative arrangements for meeting the water requirements without even questioning the authorities concerned. This, in turn, has made more provision for water business with poor regulations on exploitation. There is adverse impact on the local environment due to the indiscriminate exploitation of groundwater. Quality impacts on the

environment and health of the people have been awfully neglected with poor evidence. It is imperative that a holistic approach towards water management is implemented as per the designed guidelines. The matter requires serious attention of the policy makers, environmentalists, academicians, NGOs and concerned citizens as a coordinated effort to make the water institutions accountable.

Annex 1
Study Area – An Overview

Cities	Location	Altitude in metres above MSL	Population in lakhs (2001 census)	Population density (persons per Km^2)	Number of house-holds in lakhs	Number of wards
Hubli	Northwestern part of Karnataka at North latitude 15° 9¹ to 15°14¹ and east longitude of 75°15¹ to 75° 36¹	670.75	5.21	4,647	1.04	45
Dharwad	Northwestern part of Karnataka at North latitude 15°19¹ to 15° 14¹ and east longitude of 75°15¹ to 75° 36¹	762.19	2.64	4,647	0.52	22
Belgaum	Located at longitude of 74° 30¹ and latitude 15° 51¹	710	3.99	4,200	0.91	58
Kolar	Between 12⁰46¹ and 13⁰58¹ north latitude and 77⁰21¹ and 78⁰35¹ east longitude.	831.15	1.13	445 persons/ ha	0.29	31

Annex 2

Impacts of Contamination

Physico-Chemical Parameter	Possible Impacts
Turbidity in NTU	Unsuitable for domestic purposes because it causes stains on clothes, sinks etc. Makes treatment difficult and costlydue to increase in chemical coagulation costs and increased cleaning of filters.
PH	It affects the taste, corrosivity, efficiency of chlorination, and treatment process such as coagulation. Low pH increases corrosive action of water.
Total Dissolved Solids	High concentration could result in physiological disorders. Also results on formation of scales and interface with the taste and colour.
Total Hardness (as CaCO3), mg/l	The hardness is responsible for the formation of incrustation in utensils, scales in boilers, hot water pipes and heaters.
Chloride (as Cl), mg/l	Produces a salty taste to the water disease of heart or kidneys
Sulphate (as SO4), mg/	Imparts a bitter taste to the water. Sulphate as magnesium sulpahte causes laxarive effects to children particularly in hot weather.
Fluoride (as F), mg/l	Cause mottled tooth enamel in children and adults
Nitrate (as NO3), mg/l	Causes poisoning in infant animals including humans (methemoglobinemia). The disease “cyanosis” in which the haemoglobin apparently becomes incapable of transporting oxygen is also attributed to high concentration of nitrate.
Calcium (as Ca), mg/l	Undesirable for household uses such as a washing bathing and laundering because of the consumption of more soap and other cleaning agents.
Magnesium (as Mg), mg/l	High concentration causes unpleasant smell to the water and have laxative effects to children in combination with sulphate salts.
Iron (as Fe), mg/l	One of the troublesome minerals and high levels leaves brown stains on porcelain, clothes.
Microorganisms	Causes water borne diseases like Hepatitis, cholera, typhoid, diarrhoeal, etc

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