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# Wastewater usage in urban and peri-urban agricultural production systems: scenarios from India

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**Abstract**

The role urban and peri-urban agriculture (UPA) plays in reducing urban poverty and ensuring environmental sustainability was recognized by the Millennium Development Goals (MGDs). India is the world's largest democratic nation with a population of 1.2 billion. The rapid urbanization and high proportion of people below the poverty line along with higher migration to urban areas make India vulnerable to food crisis and urbanization of poverty. Ensuring jobs and food security among urban poor is a major challenge in India. The role of UPA can be well explained and understood in this context. This paper focuses on the current situation of UPA production in India with special attention to wastewater irrigation. This question is being posed about the various human health risks from wastewater irrigation which are faced by farmers and labourers, and, secondly by consumers. The possible health hazards involve microbial pathogens as well as helminth (intestinal parasites). Based on primary and secondary data, this paper attempts to confirm that UPA is one of the best options to address increasing urban food demand and can serve to complement rural supply chains and reduce ecological food prints in India. "Good practice urban and peri-urban agriculture" necessitates an integrated approach with suitable risk reduction mechanisms to improve the efficiency and safety of UPA production.

## Introduction

The significant role of urban and peri-urban agriculture (UPA) in the fulfilment of the Millennium Development Goals (MGDs), especially reducing urban poverty and hunger (MDG 1) and ensuring environmental sustainability (MGD 7), has been well recognized (Von Braun et al., 2004; Mougeot, 2005). "Urban and peri-urban agriculture can be broadly defined as the production, processing and distribution of foodstuff from crop and animal production, fish, and ornamental flowers within and around urban areas" (Mougot, 2000). UPA production systems were based on intensive and high input management practices on scarce lands (Smith et al., 1996; Pearson et al., 2010) depending on limited resources including water (Smit and Nasr, 1992). The achievement of food security can be asserted by increasing production, preventing post-harvest losses, improving the distribution network and enabling accessibility of food to poor people. The UPA can potentially fill the hunger gap by enhancing the access to and distribution of food in urban areas (Lee-Smith, 2010). Initially urban agriculture was started as a part of leisure time activity as well as subsistence in world wars; a radical transformation of the objectives of UPA occurred during the early 1980s (Figure 1 and 2). In African countries especially Nigeria (Kano), Zimbabwe (Harare), and Tanzania (Dar-Es-Salaam) UPA became an integral part of the permanent landscape (Smith, 2001; Bryld, 2003). The driving force behind the transformation in UPA towards market oriented production is the increase in urban population

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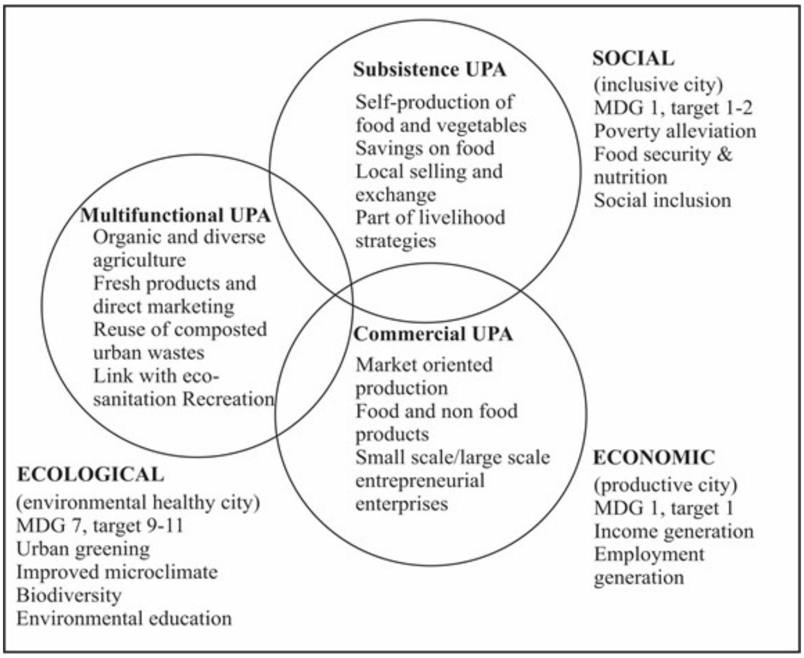


**Figure 1:** Social, ecological and economic dimensions and various types of urban and peri-urban agriculture (modified after; De Zeeuw et al., 2011)

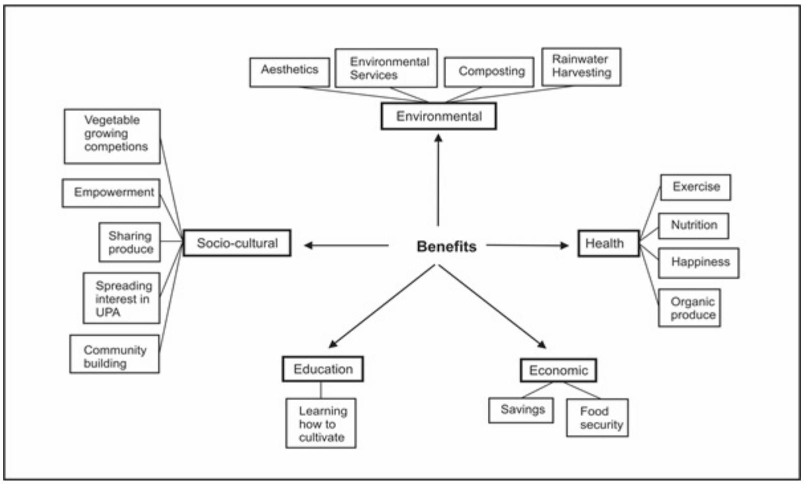


**Figure 2:** Benefits and services offered by various types of urban and peri-urban agriculture (modified after; Devenish, 2009)

and poverty (Cohen, 2006; Obuobie et al., 2006; Hill et al., 2007; Sinha, 2009; Ward, 2013).

UPA production systems may reduce the ecological foot print of cities and allow for synergies between urban domestic and industrial sectors (Jansen, 1992; Midmore and Jansen, 2003; De Zeeuw et al., 2011). More than 800 million farmers are in involved in UPA production, of which 200 million depend on wastewater for irrigation (UNDP, 1996; Bahri, 2009). The use of non-treated wastewater and industrial pollution make this system much more prone to high level heavy metals and microbial load thereby challenging the quality of urban produce (Diogo et al., 2010; Abdu et al., 2011a; Abdu et al., 2011b; Kiba et al., 2012; Safi and Buerkert, 2012). Our objectives of the study were (1) to give an overview of the UPA production systems in India which are irrigated with wastewater (2) to compare the status quo of heavy metals present in different locations where UPA is practiced in India.

## Methodology

The methodology used in this paper was based on primary and secondary data from various resources. In this paper, we review the current status of UPA production in

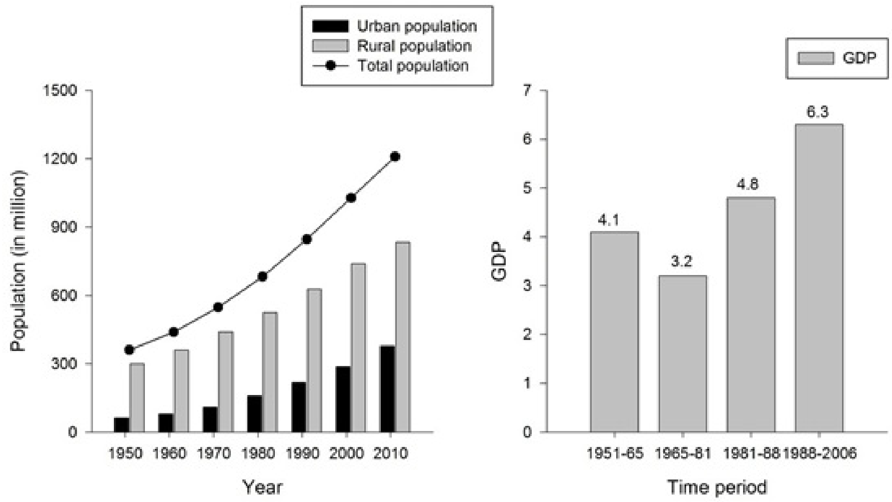


**Figure 3:** Population growth and Gross Domestic Product (GDP) growth in India from 1950 to the 2000s (after Panagariya, 2008)

India using wastewater as an irrigation source. We collected different research articles and books from multiple academic databases. Thus, this paper built partially on our own research work as well as on a literature survey. The negative impacts on environment and health using wastewater were also mentioned. The results were analysed by descriptive statistics using SPSS 12.0 (SPSS Inc., Chicago, IL, USA) and graphs were generated using Sigma plot 7 (Systat Software Inc., Chicago, IL, USA).

## Urbanization in India

India is the world's largest democratic nation with a population of 1.2 billion (Figure 3) where one third of the poor still lives below the poverty line of 1 US$ per day (Datt and Ravallion, 2002; Deaton and Dreze, 2002; Census India, 2011). The current growth rate, genie coefficient and multidimensional poverty index of India is 4.0, 36.8 and 0.28 respectively (Krueger, 2008; Panagariya, 2008). In 1950, it was estimated that 82% of the total population lived in rural areas and agriculture contributed 56% of the Gross Domestic Product (GDP). While in 2010, due to rapid urbanization the rural population declined to 70%, the urban population keeps increasing at a faster rate (Panagariya, 2008; Census India, 2011). The major populated metropolitan regions in India (Table 1) include the National Capital Region (NCR), Mumbai Metropolitan Region (MMR), Kolkata Metropolitan Region (KMR), Chennai Metropolitan Region (CMR), Bangalore Metropolitan Region (BMR) and Hyderabad Metropolitan Region (HMR). Based on the above facts, current population growth and relevance of UPA, our research question deals with the safety aspect of wastewater irrigation in UPA production systems in India.

By 2025 India is expected to be the world's most populous country, thus bringing down the land to man ratio even further. The urban population will surpass the rural population in the course of the next decade. Land will become a more scarce resource for the farmers in the peri-urban areas and subsequently villages were transformed to urban areas. India's rate of urbanization is estimated to be about 3.5% per annum (Datt and Ravallion, 2002; Panagariya, 2008). The projection is that by 2020, about 50% of the total population of India will live in urban areas. Population explosion and the migration of people towards urban area create more pressure on food, shelter, water and basic necessities (Cohen, 2006). Migration from rural area to urban area is a common phenomenon in India, where people look for better employment, education, services and financial gain. Transformations in villages, alternative jobs in construction and various industries, poor productivity in agricultural labours seeking better job opportunities and climate change are some key factors triggering the decline of farming activities in rural and peri-urban areas (Sharma and Bhaduri, 2006; Martin, 2010).

It is estimated that Indian cities will generate 70% of the new jobs and 70% of Indian GDP in the year 2030 (McKinsey Global Institute, 2010). Employment and surging growth in Indian cities drove their population to 340 million in 2008 and could reach 590 million by 2030 (Panagariya, 2008). Poverty and a lack of gainful employment in rural areas drive people to the cities for work and livelihood (Bhowmik, 2000). Five states in India will have more than 50% of urban population including Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab by 2030 (McKinsey Global Institute, 2010).


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**Figure 4:** Major UPA production systems from India: (top left), Railway Garden (RG) from the Mumbai Metropolitan Region; (top right), RG irrigated with wastewater; (middle left), farmers washing the white radish harvested from RG; (middle right), wastewater lagoon for fish production from Kolkata Metropolitan Area; (bottom left), mustard cultivation using wastewater in Kolkata Metropolitan Area; (bottom right), wastewater irrigation using motor pumps from lagoon in Kolkata Metropolitan Area

## UPA production in India

Urban agriculture in India is witnessing a beginning with piecemeal efforts in a few cities. Against the backdrop of tremendous population growth, haphazard and unplanned urbanization, growing food scarcity and increasing fruit and vegetable prices, there is the growing presence of urban agriculture in some form or other in every city. It is used as a resource conserving industry, where waste is converted to resource. It creates a diverse ecology where fruit trees, vegetable plants and fish production co-exist with the built environment of the urban poor, mostly migrants, making an ecologically sustainable scenario. The phenomena usually take place in the low-lying city fringes, which play important roles such as: a) controlling floods b) functioning as a workshop of 'resource conservation industry', where the open loop of thrown away garbage becomes a closed loop by converting it into resources c) supplying food and commodities to the city to keep the metabolism d) providing employment opportunities in the informal sector.

Urban agriculture can be considered one aspect for mitigating food insecurity and malnutrition among urban poor in India. In addition to livelihood opportunities, urban waste management also greatly improved (Gupta and Gangopadhyay, 2013). Usage of wastewater in agricultural production systems can significantly provide an uninterrupted supply of resources, especially irrigation water and nutrients which can offer improved crop yields (Bahri, 1999; Kretschmer et al., 2002; Bahri, 2009). The major UPA production centres in India were the six metropolitan cites (Figure 4 and 5).

### Wastewater use

Due to the shortage and demand of fresh water, wastewater is often used as a valuable resource to meet the demand. It was estimated that on a global scale about 20 million ha (hectares) of land were irrigated with wastewater (Hamilton et al., 2007). Wastewater reuse in agriculture a) provides an additional source of water, nutrient and organic matter b) reduces the discharge to the surface water c) improve the economic efficiency of investments in wastewater disposal and irrigation (Khouri et al., 1994; Verma and Rakshit, 2010). Wastewater is comprised of domestic effluents, commercial establishments, industrial effluents and urban runoff. The constituents may vary spatially and temporally depending on the climatic conditions (Scott et al., 2004). The most relevant wastewater usage includes a) direct use of untreated wastewater b) direct use of treated wastewater c) indirect use of wastewater (Figure 6 and 7). Use of wastewater for irrigation and aquaculture is considered a part of the informal sector in India and receives less attention from governments (Buechler et al., 2002; Buechler and Devi, 2003; Buechler and Mekala, 2005; Amerasinghe et al., 2013). The majority of wastewater generated in India was taken from industrial effluents. According to Strauss and Blumenthal (1990), 73,000 ha were irrigated with wastewater in India. The majority of wastewater irrigation occurs along rivers adjacent to growing cites especially Delhi, Kolkata, Coimbatore, Hyderabad and Varanasi (Scott et al., 2004).

### Wastewater usage in Hyderabad

The seasonal flow pattern of the Musi River has been lost and most of the urban wastewaters drain into the river. Currently these wastewaters were used for growing para grass (*Urochloa mutica*) and paddy (*Oryza sativa*) where fodder grass targets the urban dairy market. Other wastewater irrigated crops include banana, coconut and vegetables with an estimated area of wastewater irrigation around 200 km2 (Ensink et al., 2005; Van Rooijen et al., 2005). Along the Musi River it was estimated that 2,100 ha land were irrigated with wastewater to cultivate paddy (Mekala et al., 2008; Srinivasan and Reddy, 2009). More than 13 vegetables were also grown under waste

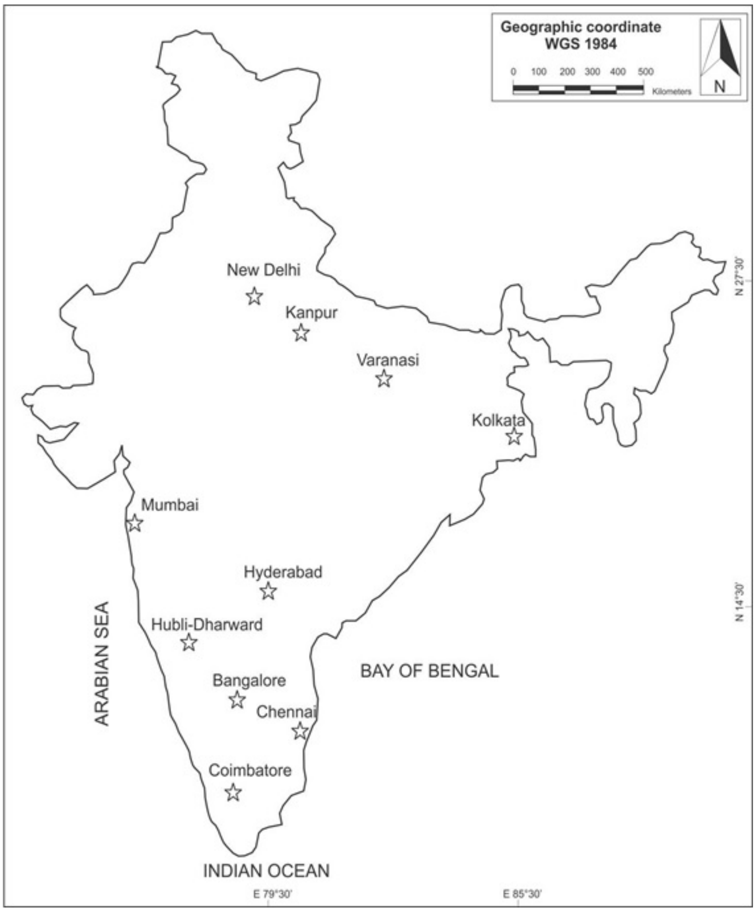


**Figure 5:** Map of India showing the location of the UPA production areas (marked as star symbol). Source: own illustration


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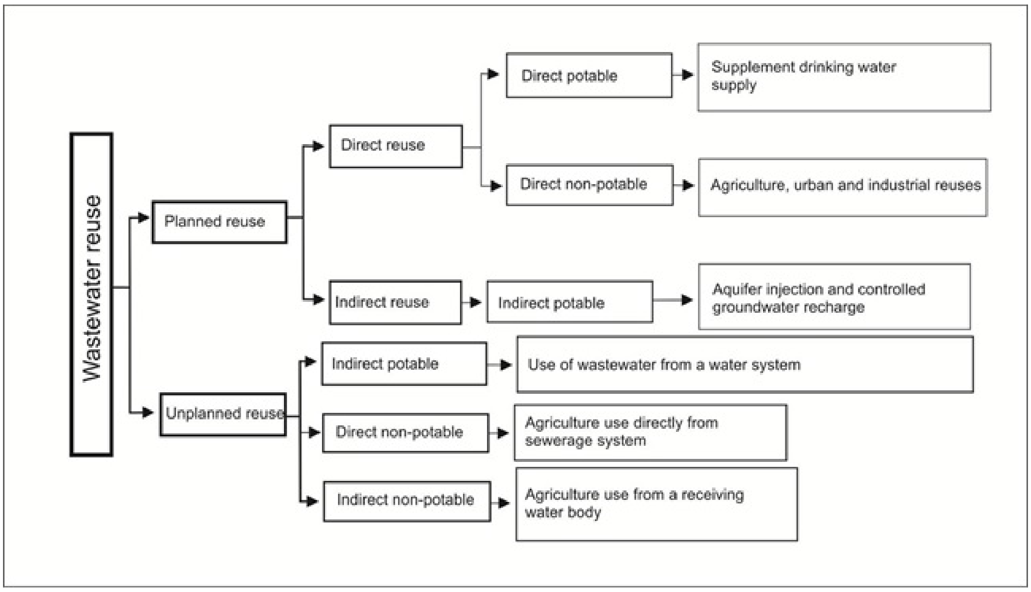


**Figure 6:** Topology of wastewater usage (adapted from Keremane, 2007)

water irrigation which includes spinach (*Spinacia oleracea L.*), malabar spinach (*Basella Alba L.*), red amaranth (*Amaranthus cruentus L.*), mint (*Mentha spicata L.*), coriander (*Coriandrum sativum L.*), lady's finger/okra (*Abelmoschus esculentus L.*), taro (*Colocasia esculenta L.*) and common purslane (*Portulaca oleracea L.*). Flower production, especially jasmine (*Jasminium officinale L.*) using wastewater is also reported by Buechler et al. (2002).

**Wastewater usage in Mumbai Metropolitan Region**

In the Mumbai Metropolitan Region (MMR) the Indian Railways plays a major role in UPA production. Under the scheme "Grow more food", the Indian Railway companies has rented since 1975 unutilized land near railway tracks and stations to railway class IV employees and non-railway employees for promoting the cultivation of vegetables and as a part of corporate social responsibility (CSR). In the MMR, about 176 hectare of land were allotted among 282 railway employees who transformed this land to productive railway gardens by growing vegetables such as okra, spinach, red amaranth and taro which were predominantly irrigated with wastewater (Table 2; Vazhacharickal and Buerkert, 2012; Vazhacharickal et al., 2013).

**Wastewater usage in Delhi Metropolitan Region**

It was estimated that 1,700 ha of land irrigated with wastewater to grow cucurbits (Cucurbita pepo), eggplant (Solanum melongena L.), okra, coriander in summer and spinach, mustard (Brassica juncea), cauliflower (Brassica oleracea L.) and cabbage (Brassica oleracea var. capitata) in the winter across the Delhi metropolitan region (Mekala et al., 2008).

**Wastewater usage in Kolkata Metropolitan Region**

The east Kolkata sewage fisheries represent the largest single wastewater usage system in aquaculture in the world (Pescod, 1992). It was estimated that 12,800 tonnes of paddy, 6,900 tonnes of fish and 0.7 tonnes of vegetables were produced in this region (Chattopadhyay, 2002; Mukherjee et al., 2013).

**Wastewater usage in Hubli-Dharwad**

Wastewater irrigated agro-forestry systems were observed in villages near Hubli-Dharward in Karnataka. The tree species include sapodilla (*Manilkara zapota*), guava (*Psidium guajava*), coconut (*Cocos nucifera L.*), mango (*Mangifera indica*), areca nut (*Areca catechu*) and teak (tectona grandis). This complex agrosilivultural system also contains neem (*Azadirachta indica*), tamarind (*Tamarindus indica L.*), banana (*Musa acuminata*), pomegrate (*Punica granatum L.*) and mulberry (Morus alba L.; Bradford et al., 2003).

**Wastewater usage in Kanpur**

During 2004 it was estimated that 2,770 farmers were involved in wastewater agriculture stretching to 2,500 ha. About 400 million litres of wastewater were discharged in Kanpur per day (Gupta, 2013).

**Wastewater usage in Coimbatore**

In Coimbatore the major wastewater irrigation can be seen near Ukkadam with a sewage farm of size 35 ha cultivated with Guinea grass (*Megathyrsus maximus*), para grass, elephant grass (*Pennisetum purpureum*) and coconut (Jeyabaskaran and Sree Ramulu, 1996; Chitdeshwari et al., 2003; Somasundaram, 2003; Malarkodi et al., 2007).

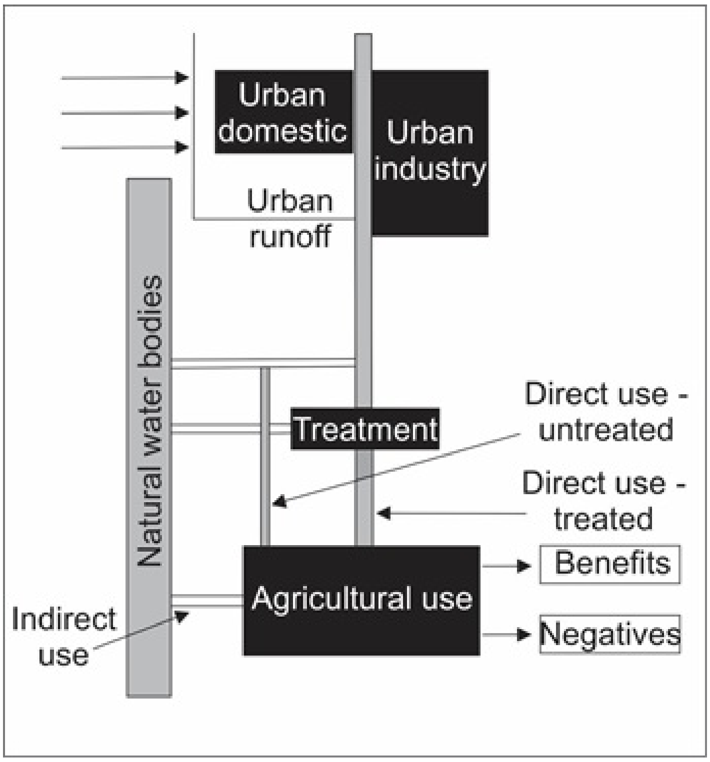


**Figure 7:** Dimensions of water usage (adapted from Scott et al., 2004)

**Wastewater usage in Varanasi**

In Varanasi it was estimated that 240 million litres of swages were generated. The major vegetables grown were radishes (*Raphanus sativus L.*), turnips (*Brassica rapa var. rapa L.*), carrots (*Daucus carota*), tomatoes (*Solanum lycopersicum L.*), cauliflower, eggplant, potatoes (*Solanum tuberosum L.*), cabbage, spinach and coriander which are targeted toward the urban market in Varanasi. The major villages using wastewater irrigation were Dinapur, Khalispur, Kotwa, Kamanli and Shiwar (Ghosh et al., 2012).

**Wastewater usage in Chennai**

The major crops were millets (*Pennisetum glaucum L.*), sugarcane (*Saccharum L.*) and paddy, (Janakarajan et al., 2010), but the usage of wastewater has not been officially reported by any authors, even though the usage with wastewater is common in peri-urban areas.

**Health hazards associated with UPA production using wastewater**

Human health risks from wastewater irrigation includes primarily farmers and labourers and secondly consumers. The possible health hazards involve microbial pathogens as well as helminth. In addition the soil and crop contamination of organic and inorganic trace elements were also reported in wastewater irrigation (Ganeshamurthy et al., 2008). Farmers using wastewater irrigation are more prone to helminthes and skin problems than a famer using fresh water. (Trang et al., 2007; Qadir et al., 2010). Continuous irrigation with wastewater may lead to heavy metal accumulation in the soil and their subsequent transfer to the vegetables (Table 3 and 4). Due to the persistent nature of these heavy metals, they may accumulate in vital organs and can cause numerous health disorders.

Concentrations of total Pb (lead) and Cd (cadmium) exceeded the safety thresholds (Table 6) in many vegetables, especially in spinach (3.8 and 1.8 mg $kg^{-1}$), green amaranth (3.3 and 0.2 mg $kg^{-1}$), white radish leaves (6.8 and 0.5 mg $kg^{-1}$), and white radish root (5.7 and 0.2 mg $kg^{1}$). In all samples analysed Hg (mercury) and Ni (nickel) were below detection limit. The presence of Pb and Cd in plant material may in the long run create health hazards for the consumers. These metals are often accumulated in leafy vegetables and root crops when compared to fruits and seeds. The supply of nutrients in the irrigation water (Figure 8) may leads to ground water leaching which may affect the apparent nutrient usage efficiency of the system.

**Management interventions for risk reduction**

Human and environmental risk of wastewater usage can be reduced by a set of combined measures. These include a) water quality improvements b) human exposure control c) farm level wastewater and d) harvest and post-harvest interventions (WHO, 2006; Qadir et al., 2010). Improvement in the quality of wastewater can be achieved by combination of primary and second-


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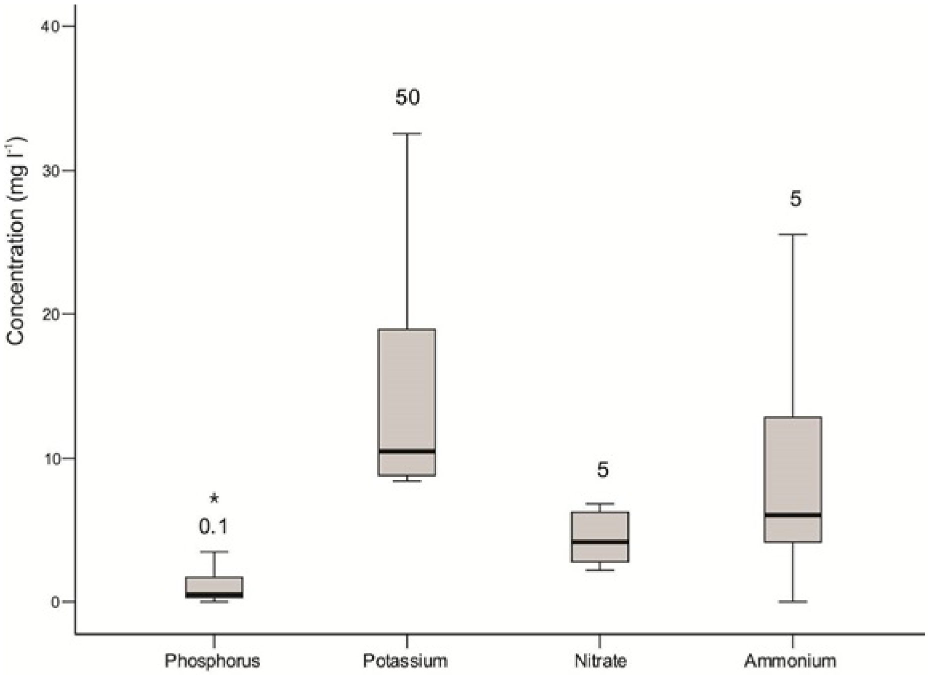


**Figure 8:** Box plot showing the chemical characteristics of the irrigation water in ten UPA production systems across the Mumbai Metropolitan Region (India) and recommended threshold levels (FAO, 2010) displayed above the whisker

ary treatment. Protective gadgets especially boots and gloves and changing irrigation methods can also lower the risk. Farm management practices including crop diversification irrigation and manure requirement also a play a vital role. Finally the harvest and post-harvest interventions can also substantially reduce the health risk (Qadir et al., 2010).

Government and public authorities lack the technical and management options to reduce the health risks associated with wastewater usage. Policies should be made to reduce the negative impacts of wastewater usage while supporting its benefits including the source as a valuable nutrient and organic matter. Management of wastewater and proper treatment will substantially reduce the possible health risks. Conducting public awareness programmes will certainly make the farmers and consumers aware of the negative aspects of wastewater irrigation thereby encouraging them to adopt hygienic management practices.

## Discussion

The contribution of UPA towards food security and employment opportunities was well appreciated in India. It is unquestionable that the UPA provides access of food to the urban poor at a cheap price. In addition to all these plus points, the usage of non-treated wastewater may impose long term health problem as well as the accumulation of heavy metals in the soils. Heavy metals were reported in various UPA production systems depending on wastewater as irrigation sources. Heavy metal contaminations in vegetables grown using wastewater were reported in Hubli-Darwad (Hunshal et al., 1997), Varanasi (Ghosh et al., 2012), Hyderabad (Srikanth and Reddy, 1991) and Coimbatore (Malarkodi et al., 2007). Consumption of vegetables with heavy metals may lead to accumulation and its long term use can pose serious health risks to the consumers. Attention is needed for the monitoring of industrial effluents, hygienic practices among farmers as well as the productive use of wastewater for irrigation. A permanent solution to prevent the heavy metals into the food chain seems to be less practicable in the Indian scenario; however, the methods should be adopted to reduce the integration of these heavy metals, particularly through wastewater treatment as well as bioremediation methods.

## Conclusions

Ensuring jobs and food security among the urban poor is a major challenge in underdeveloped and developing countries. Urban and peri-urban agriculture is one of the best options to address increasing urban food demand and can complement rural supply chains and reduce ecological foot prints.

The growing water demands and release of untreated wastewater pose a big challenge to environmental sustainability. Irrigation with wastewater is a reality and common practice in India. However, the possible health risks associated with them should receive attention from the policy makers and stakeholders. An integrated approach with suitable risk reduction mechanism would improve the efficiency and safety of these UPA production systems which can be called "Good practice urban and peri urban agriculture".

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## Appendix

**Table A1:** Major metropolitan areas in India and their characteristics during the year 2011 (KMDA, 2012)

| Rank | Metropolitan area | State/Territory | Governing authority | Area (km2) | Population | Population density (km2) |
|---|---|---|---|---|---|---|
| 1 | National Capital Region (NCR) | Delhi, Uttar Pradesh, Haryana | Delhi Development Authority (DDA) | 1,483 | 21,753,000 | 9,340 |
| 2 | Mumbai Metropolitan Region (MMR) | Maharashtra | Mumbai Metropolitan Region Development Authority (MMRDA) | 4,355 | 20,748,000 | 4,764 |
| 3 | Kolkata Metropolitan Area (KMA) | West Bengal | Kolkata Metropolitan Development Authority (KMDA) | 1,886 | 14,617,000 | 12,883 |
| 4 | Chennai Metropolitan Area (CMA) | Tamil Nadu | Chennai Metropolitan Development Authority (CMDA) | 1,189 | 8,728,000 | 5,921 |
| 5 | Bangalore Metropolitan Area (BMA) | Karnataka | Bangalore Development Authority (BDA) | 1,276 | 9,645,000 | 7,600 |
| 6 | Hyderabad Metropolitan Area (HMA) | Andra Pradesh | Hyderabad Metropolitan Development Authority (HMDA) | 7,100 | 7,749,000 | 7,826 |


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**Table A2:** Vegetables cultivated in UPA railway gardens of the Mumbai Metropolitan Region, India (Vazhacharickal et al., 2013)

| Serial No | Common name (English) | Local name (Hindi) | Botanical name |
|---|---|---|---|
| 1 | Lady's finger/Okra | Bhindi | *Abelmoschus esculentus L* |
| 2 | Spinach | Palak | *Spinacia oleracea L* |
| 3 | Red amaranth | Lal Maat | *Amaranthus cruentus L* |
| 4 | Fenugreek | Methi | *Trigonella foenum-graecum L* |
| 5 | White radish | Mula | *Rhaphanus sativus var. longipinnatus* |
| 6 | Malabar spinach | Mayalu | *Basella alba L* |
| 7 | Green amaranth | Chawli | *Amaranthus tritis* |
| 8 | Sorrel leaves | Ambaadi | *Hibiscus sabdariffa L* |
| 9 | Taro | Alu | *Colocasia esculenta L* |
| 10 | Dill | Shepu | *Anetthum graveolens L* |

**Table A3:** Heavy metal concentrations in irrigation water collected from 10 UPA production systems in the Mumbai Metropolitan Region and recommended threshold levels.

| Heavy metal * | Mean | SD | Min | Max | Thresholds | |
|---|---|---|---|---|---|---|
| Lead (Pb) | 0.03 | 0.02 | 0.00 | 0.06 | 0.2 †a | 0.05 ‡b |
| Cadmium (Cd) | 0.38 | 1.08 | 0.00 | 3.47 | 0.05 †a | 0.003 ‡b |
| Mercury (Hg) | 0.003 | 0.001 | 0.001 | 0.005 | 0.002 †b | 0.006 ‡b |

* All values in mg $l^{-1}$
a Agricultural Standards
b Domestic Standards
† Department of Water Affairs and Forestry (1996), South African Water Quality Guidelines
‡ FAO (2010)

**Table A4:** Total cadmium (Cd), lead (Pb), copper (Cu), zinc (Zn), chromium (Cr) and nickel (Ni) concentrations in the surface soil (0-20 cm) of seven UPA production systems across the Mumbai Metropolitan Region, India

| Data | Cd | Pb | Cu | Zn | Cr | Ni |
|---|---|---|---|---|---|---|
| | (mg kg$^{-1}$) | | | | | |
| Mean | 0.4 | 3.8 | 146 | 133 | 429 | 135 |
| SD | 0.4 | 1.4 | 54 | 21 | 209 | 72 |
| Max | 1.1 | 6.9 | 231 | 161 | 791 | 247 |
| Min | 0.1 | 3.3 | 60 | 103 | 114 | 1.1 |
| Thresholds | | | | | | |
| India† | 3-6 | 250-500 | 135-270 | 300 | na | 75-150 |
| EU‡ | 3 | 300 | 140 | 600 | 150 | 20-100 |
| UK‡ | 3 | 300 | 80-200 | 300 | 400 | 50-110 |
| USA‡ | 20 | 150 | 170 | 1400 | na | 210 |

**Table A5:** Total heavy metal content in soils of various UPA production system across India (modified after; Ganeshamurthy et al., 2008)

| Locations | Zn | Cu | Cd | Pb |
|---|---|---|---|---|
| | (mg kg$^{-1}$) | | | |
| Bangalore | 71.8 | 3.52 | 0.35 | 35.2 |
| Kolkata | 1300 | 160 | 4.0 | 170 |
| Varanasi | 87.9 | 33.5 | 2.7 | 18.3 |
| Coimbatore | 397.4 | 157.1 | 8.1 | 175.5 |
| Hyderabad | 2.9 | 4.3 | 0.4 | 8.1 |
| PFA standard | 300-600 | 135-270 | 3-6 | 25-50 |

**Table A6:** Concentrations of total copper (Cu), zinc (Zn), chromium (Cr), lead (Pb) and cadmium (Cd) in green amaranth, spinach, white radish and paddy (mg kg-1 dry weight) from UPA production systems (n=4) across the Mumbai Metropolitan Region, India

| Data | Cu | Zn | Cr | Pb | Cd |
|---|---|---|---|---|---|
| | (mg kg$^{-1}$) | | | | |
| Mean | 7 | 40 | 4 | 5 | 0.6 |
| SD | 4 | 34 | 4 | 2 | 0.7 |
| Max | 13 | 96 | 11 | 7 | 1.8 |
| Min | 3 | 9 | 1 | 3 | 0.1 |
| Safety thresholds | | | | | |
| WHO† | 40 | 50 | na | 0.3 | 0.2 |
| India ‡ | 30 | 50 | 20 | 2.5 | 1.5 |


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