(capítulo do livro Urban Drainage in Humid Tropics que erá publicado pela UNESCO)

2. Urban drainage issues in developing countries

by Carlos E. M. Tucci

2.1 Urban development

The tropic is the region between the tropic of Cancer and tropic of Capricorn (23º 27' N and 23º 27' S of the equator). This area include countries such as: Brazil, Colombia, Costa Rica, Mexico, India, Myanmar, Thailand, Congo Cameroon, Vietnam, Malaysia and Indonesia.

There are many classifications of the tropical climate, in the following chapter are described its main characteristics. Usually *humid tropics* are characterized by a wet climate for more than seven months a year, an annual rainfall greater than 2,000 mm and a high mean temperature every month of the year. These conditions are found in regions near the equator such as: the Amazon Basin in South America, the Congo Basin in Africa, the Malaysian Peninsula and Indonesian islands of Southeast Asia (Hufschmidt and Kindler, 1991). *Subhumid* is characterized by 4 to 7 months of wet season in a year with rainfall greater than evapotranspiration.

Most of the countries in the tropics are usually classified as *developing,* based on social economic indicators. In figure 2.1 the population growth for developed and developing countries is presented and the forecast until 2150. In developing countries the population increase is still high and the trend to stabilization was forecast only for after 2150.

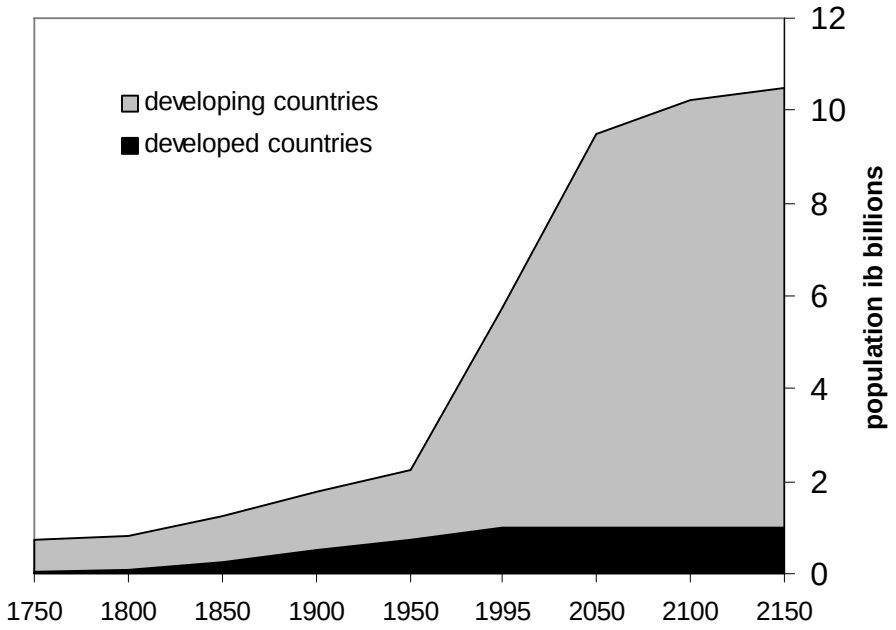

Figure 2.1 Population growth (The Economist, 1998 with UN source)

In 1900, only 15% of the world's population lived in cities; today the percentage is more than 50% and the United Nations forecasted that between 1990 and 2025, the urban population will rise to over 5 billions, 90% of that in developing countries.

In Africa and Asia, more than half of the population still lives in rural areas. In Latin America and the Caribbean countries, urban population growth is from 3 to 5% a year, and in Brazil, the urban population is close to 80%, equal to that of North America and Europe. By the year 2000, between 30 and 35 of the world cities are expected to have over 10 million inhabitants (Foster, 1986). By the year 2010, the forecast is for 60 cities with more than 5 millions, most of those cities in developing countries. The main cities in the world are presented in figure 2.2, and some of this cities are in the tropics. The most populated cities in the world are presented in table 2.1 (greater than 10 millions) and most of these cities are inside of the tropics.

Urban development in developing countries presents a high population concentration in small areas, poor public transportation, lack of some water facilities, polluted air and water. These poor environmental conditions are the main concern for quality of life in these areas.

A major part of this population lives in squatter settlements (*favelas* in Brazil or *barrios* in Venezuela). Caracas has over than 50% of its population in this type of area and New Delhi about 20%. These slums are built out of cardboard and scrap material in hazardous areas such as flooded lands and steep hillsides. After a few years this kind of construction improves and better material is used but the settlement is a labyrinth of small streets without any planning for water supply, waste disposal and drainage (The Economist, 1998).

In table 2.2 are presented some urban developments indexes for several countries in the tropics. In most of these countries the urban concentrations are above 50%.

OECD, United Nations and the World Bank identified some social goals as part of a new international development strategy (table 2.3). Most of these goals are related to urbanization and water issues.

Table 2.1 Most populated cities in the world

City	Population Millions
Tokyo	27,8
Bombay	18,0
Sao Paulo	17,8
Shanghai	17,0
New York	16,6
Mexico City	16,3
Peking	14,2
Djakarta	14,0
Lagos	13,5
Los Angeles	13,0
Calcutta	12,6
Tianjin	12,0
Karachi	12,0
Seoul	12,0
New Delhi	11,6
Buenos Aires	11,3
Manila	10,8
Cairo	10,7
Osaka	10,6
Rio de Janeiro	10,2
Dacca	10

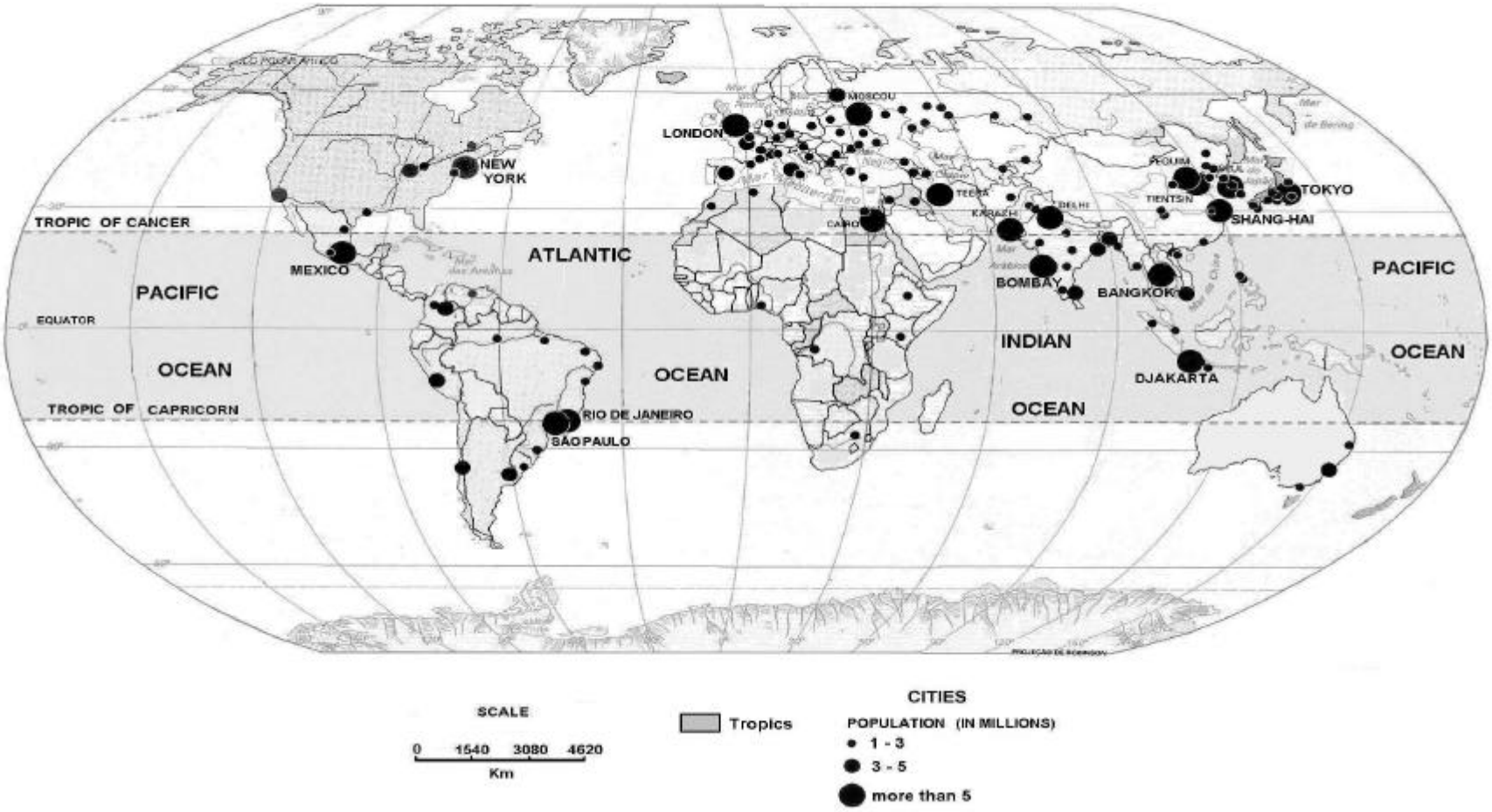

Figure 2.2 Largest cities in the world

Table 2.2 Urban Indicators (World Bank WDI, 1999)

Countries	Population (1997)		Population in cities with population with more than one million % of urban population			Population in the largest city % of urban population		Access to sanitation in urban areas % of urban population	
	In millions	urban population %	1980	1995	2015	1980	1995	1980	1995
Brazil	130,1	80	27	33	34	16	13	33	74
Cameroon	6,5	46	6	10	14	19	22	-	-
Colombia	20,4	74	21	27	27	20	22	96	70
India	264,1	27	6	10	12	5	6	25	-
Indonesia	74,8	37	7	13	16	18	13	30	85
Malaysia	11,9	55	7	6	7	16	11	-	94
Peru	17,5	72	26	32	33	39	40	67	78
Philippines	41,1	56	12	13	14	33	24	-	88
Thailand	12,5	21	10	11	15	59	55	50	98
Venezuela	19,7	86	16	27	28	21	16	57	74
Vietnam	15,0	20	5	6	9	27	25	-	-

Table 2.3 International goals for world development (World Bank, 1999)

Goals	Indicators
Poverty reduction	Reducing by half the proportion of people in extreme poverty by 2015
Reduction of Infants mortality	Reducing by two-thirds the mortality rates for infants and children under 5 and by three-fourths the mortality rates for mothers by 2015.
Improve education	Achieving universal primary education in all countries by 2015.
Improve health	Providing access to reproductive health services for all individuals of appropriate age no later than 2015
Gender equality	Demonstrating progress toward gender equality and the empowerment of women by eliminating gender disparities in primary and secondary education by 2005.
Environment protection	Implementing national strategies for sustainable development by 2005 to ensure that the current loss of environmental resources is reversed globally and nationally by 2015.

2.2 Water issues

In table 2.4 are presented the main water aspects related to urban areas in developing countries, main issues and the control alternatives. These conditions are highly interrelated since the sewers are usually the main source of contamination of water sources. The urban water problems are mainly due to the following:

- Low investments in urban drainage facilities;
- Increase in peak and flood frequency due to inadequate drainage management and design;
- Lack of drainage and other sanitary facilities for poor population.

In 1990 in developing countries, 81% of the urban areas and 58% of the rural areas had access to a safe water supply; 71% of the urban areas and 48% of the rural areas had access to sanitation. For developing countries water supply covers was about 80% and only 10% for sewage, but a billion people still do not have access to clean water. In 1990, 453 millions did not had access to sanitation which was 33% of the population. In four years 70 millions received sanitation but the population grew from 1.4 to 1.6 millions, increasing the proportion of population with lack of sanitation in these countries to 37% (Wright, 1997). Clearly, water and waste treatment are important issues in these countries.

Population growth is one of the major problems in urban water resources planning. The lack of safe water is increasing mainly because of :

- water demand increase based on population growth;
- degradation of water (aquifer and rivers) caused by waste disposals;

In 1990, 20 countries experienced water scarcity (available per inhabitant less than 1,000 $m^3.yr^{-1}$). By 2025, 44 per cent of the world's population will live in countries with physical scarcity, and 26% will live in countries with economic scarcity (Seckler, 199). The World Bank has forecasted that this number will increase by the year 2025 to 34, most of them in North Africa and Middle East in the Humid Tropics (The Economist, 1998).

For developing countries, as mentioned above, the cost and the development of sanitation still is a major challenge. Sanitation coverage is one of the key indicators of urban poverty since overcrowded and unhealthy living conditions of the urban poor in developing countries

are made even more degrading by the lack of adequate systems to dispose of human wastes (Wright, 1997). The total coverage may look good but most of the sanitation is for the wealthy areas of the cities and the poor lack all the basic facilities for proper living.

Table 2.4 Water aspects in urban areas of developing countries and its main alternatives and issues

Water	Alternatives	Main issues
Sources	• Surface flow • Groundwater	Contamination from domestic, industrial and agriculture waste
Water supply	• Treatment plants and water supply network; • Well supply with some treatment	• Water losses due to network leak; • water contamination by chemical compounds
Sanitation	• Network and major treatment plants • Condominium waste treatment • Well disposal without treatment • Network and disposal without treatment	• Sewer networks without waste treatment; • Groundwater contamination • Lack of waste treatment
Drainage	• Separate sewer • Combined sewer • No storm sewer	• Overflow of combined sewers; • In separate systems part of the sewage flow is linked into the storm sewers; • Lack of flow control when urbanization increases
Flood hazard	• Structural • Non-structural	• Flood valley occupation with urbanization; • Lack of Law enforcement in flood zoning

Wright (1997) evaluated the approach used in developing countries for sanitation and his main conclusions are:

- *Supply drive approach* in which the planning and construction are done based on practices in developed countries and do not take into account user needs, resulting in bad investments, lack of cost recovery and financing of new investments. For instance, in Accra, Ghana, after 20 years only 130 connections were made to a sewerage system designed for 2,000 connections;
- *Lack of management* difficulties in financing, little contact with customers, centralisation;
- M*acro versus micro projects:* high cost projects in which the cost recovery is not affordable for poor population;
- *Poor system performance:* operation and maintenance of the systems do not present an appropriate performance. The author's suggestions were: broader choice of technology options; recognition and analysis of consumers' willingness to pay for perceived benefits; optimum coverage with economic efficiency; innovative financing mechanisms and institutional frameworks; capacity building at all levels; increase user participation.

In most developed countries, quantitative aspects of urban drainage are no longer an issue, the emphasis nowadays being the control of the urban drainage water quality. However, for developing countries access to sanitation is still the important issue, urban waste disposal without treatment is decreasing the amount of clean water available for supply and new in-

vestments have to be made to maintain and improve supply. Table 2.5 shows the comparison of develop and developing countries for each aspect of water in urban areas.

In urban drainage and flood control the main issue for developed countries usually is water quality contamination and for developing countries quantitative aspects have been the main problem due to related damage.

Table 2.5 Comparison of urban water facilities between developed and developing countries

Urban Water Facility	Developed	Developing
Water Supply	Solved	For some countries water shortage is the main problem
Sanitation	Solved	• 63% of urban population has access to sanitation; • when there are sewer network waste treatment does not exist and when there are treatment plant it does not collect the designed sewage; • high groundwater contamination
Urban drainage (stormwater drainage)	• quantity control solved and; • water quality control is the main issue	• quantity control is a issue; • designed without source control; • storm sewers have been used for domestic waste disposal; • lack of storm sewer • usually there is no control on water quality from urban drainage.
Flood Hazard	mainly non-structural measures with insurance, zoning and flood alert	• occupation of flood plain without control; • bad investments in structural solutions; • occupation by the poor during drought season and high impact during flood season; • lack of management on non-structural solutions.

2.3 Urbanization impact on the urban drainage

The main issues in developing countries is urban development without planned drainage. Its consequences are the followings:

- population settlements on river flood plains, with increased flood damage;
- Increase on flood frequency due to basin urbanization;
- degradation of urban areas due to erosion and sedimentation;
- water quality impact from wash-load of urban surface and solid waste.

Peak and volume impacts

One of the main examples is the Tiete River through the city of Sao Paulo. The valley of this river has been occupied since the beginning of the century. By increasing the river flow capacity, the Government was able to reduce the frequency of flood occurrence for several years, so that population density increased in both the flood plain and upstream areas. Frequency of flooding, and the magnitude of flood peak flows, increased again, following urbani-

zation. Today, during the rainy season, there are more than five events per year causing extensive damage both to private property and public infrastructure, high cost through traffic congestion, and lost income due to difficulties in mobility. The cost to date of increasing main channel capacity has been greater than US $ 1 billion.

Brazilians cities, and in some others countries in the humid tropics, have been developed according to Urban Master Plans, which usually do not consider the impact of urbanization on drainage flow. Impervious areas from urban development upstream also produces effects downstream, where flooding peak increase.

City engineering departments commonly do not have the hydrologic support to cope with this problem and engineering works - such as channels, pipes installations - are designed without taking potential downstream impacts into account, where built-up areas leave no space into which flow could be diverted during flood events, as a means of decreasing peak flows.

Besides the failure to plan drainage networks adequately, municipality encounter many difficulties in enforcing legislation. These difficulties are due to the following:

- *large increase in urbanization*: most new developments within in the city boundaries are not approved by the township and do not have the required stormwater and sewer networks. This arises from lack of control and law enforcement;
- *invasion of public areas*: public areas, such as planned green areas, become occupied by poor and homeless people who settle there;
- *occupation of flow conveyance areas*: during periods when no floods occur, low-lying and other areas that might be reserved for flood-water dispersal are taken for poor-quality dwellings. These areas have high potential risk for damage and loss of life. (figure 2.3).

Figure 2.3 Slums in urban natural channel in Moinho Creek in Porto Alegre, Brazil

The downstream impact of such informal urban constructions is not usually very large, but they are located in high risk areas since they commonly lie close to rivers where flooding is frequent, or on unstable hill-slopes with the risk of landslides during the rainy season.

Sediment and total solids

Sediments and total solids in urban areas are mainly produced in two stages:

Urban development: when sediment production is due to lack of soil protection during urban construction. It is much more critical in the tropics since rainfall intensity is higher and the wet seasons are longer with many days of high intensity rainfall. In some regions such as the State of Parana in Brazil, it had a high impact on the cities during the 70's. A major erosion control program was developed in the State in order to control the impact of urban areas. Sediment production in some Brazilian cities is presented in table 2.6.

Tabel 2.6: Estimate of sediment deposited in the urban drainage of some Brazilian cities

River and city	Characteristics of the source	Volume $m^3/km^2.year$	Reference
Tietê River in São Paulo	Dredge sediment	393	Nakae e Brighetti (1993)
Tietê River tributaries in São Paulo.	Bed sediment	1400	Lloret Ramos et al. (1993)
Pampulha Lake in B. Horizonte	Sediments from 1957 to 1994	2436	Oliveira e Baptista (1997)
Dilúvio Creek in Porto Alegre	Dredge sediment	750	DEP (1993)

Developed urban area: when the urban area is already developed, the solids produced in the basin are due mainly to garbage washed from urban surfaces. Total solids in this stage is function of: the frequency of garbage collection and cleaning of street surfaces; public disposal of garbage; and rain frequency. Garbage production in Brazil is about 1.0 kg/person/ day: there is no information as to how much of this amount is washed off to the stormwater system. In San Jose, California (USA) litter accumulates at a rate of 4 lb/person/year in urban areas and of this total, about 1.8 lb/person/year appears in the curb lines of streets (Larger et al, 1977). For developing countries, the rates of litter in the streets should be greater than the above number, since in some parts of the cities the stormwater system is used for garbage disposal.
One of the main causes of flooding in urban drainage in cities in developing countries are the decreased hydraulic capacity of the stormwater drainage due to conduits and trash filling the channels during floods (figure 2.4 and 2.5).

Some of problems related to sediments and total solids in the urban environment of cities in developing countries are:

- urban occupation in risk areas such as hill slopes. Without drainage, after several days of rain, landslides destroy houses and kill people and increase the sediment yield to downstream drainage;
- lack of a reliable garbage collection and disposal. Part of the population in poor neighbourhood dumps the trash on streets and in the drainage system ;
- lack of street cleaning or its low frequency;
- lack of control in construction sites.

Figure 2.4 Urban drainage as a solid waste disposal (Moinho Creek in Porto Alegre, Brazil)

Figure 2.5 Garbage and population living in risky areas

Urban drainage water quality

Stormwater, sewage and garbage disposal are not closed related in good urban management, but in developing countries usually they have a strong relationship due to the lack of public facilities and services related to water.

Usually, on dry weather periods only sewage flows in the stormwater drainage and on rainy days the surface wash-load is mainly from litter and other streets detritus. Table 2.7 shows a comparison of United States cities and Porto Alegre in Brazil for some water quality parameters.

Urban sanitation networks are usually classified as separate and combined pipe networks. In the former, stormwater and sewage pipe networks are separate. In a combined network, sewage and stormwater flows are in the same pipe. In table 2.8 are presented the main characteristics of these systems and their conditions in different regions and countries.

Separate system: for a small urban concentration septic tanks are used for sewage disposal and the rainfall is drained by stormwater networks or streets gutters. Under this situation the wash-load from urban surfaces is dumped without any treatment into rivers near the cities. When the city grows, sewage networks and treatment plants are required, but usually they are not developed and the population used to discharge the domestic sewage load into the stormwater systems which works as a combined sewer system. Since it was designed for a 2 to 5 year recurrence time, it does not have a high overflow frequency, but during dry summer days the odor is bad because the drainage flow is mainly sewage. This situation is worse in the humid tropics where the temperature is high all year long. This unhealthy situation increases the probability of water related diseases.

Tabel 2.7 Comparison of mean values of water quality parameters from stormwater in several United States cities and Porto Alegre (Brazil) (mg/l)

Parameter	Durham (1)	Cincinnati (2)	Tulsa (3)	P. Alegre (4)	APWA (5) Interval	
					Lower	Upper
DBO		19	11,8	31,8	1	700
Total solids	1440		545	1523	450	14.600
Ph		7,5	7,4	7,2		
Coliform(NMP/100 ml)	23.000		18.000	$1,5x10^7$	55	$11,2x10^7$
Iron	12			30,3		
Lead	0,46			0,19		
Ammonia		0,4		1,0		

1.Colson (1974; 2 – Weibel et al. (1964); 3 – AVCO (1970), 4 – Ide (1984); 5 – APWA (1969)

In some cities in developing countries, investments in sewer network there are not followed by construction of treatment plants. In this situation, a concentrated waste load enters the main river, increasing the local impact.

Wright(1997) described the situation of Manila (Philippines) and Djakarta (Indonesia), humid tropics cities with population of about 10 million which does not have sewer systems. In this situation, middle class households have been using septic tanks. Building regulations require that septic tanks have soil adsorption systems, but since the regulations are not enforced the septic effluents overflow into rivers through storm drainage systems.

Combined systems: combined system overflows (CSO) are used by cities with old drainage systems. These systems were designed for small discharge much more related to the sewage flow than to stormwater. Urbanization and lack of source control in the drainage, increase the overflow frequency, together with damages and water related diseases. In combined systems flood control by detention is greater than in separate systems since the storage is underground.

Tabel 2.8 Sewage and drainage systems

System	Urban concentration	Sewage system	Storm drainage	Regions and countries	Main impacts
Separate	Small	Septic tank	Source control, Stormwater network with storage and water treatment	Small communities in some developed countries	Groundwater contamination
			Stormwater network	Small communities in developing countries	Contamination of the groundwater and surface water.
			Street gutters	Small communities in developing and poor countries	Contamination of the groundwater, surface water and the streets. Potential disease proliferation
	Medium to high	Sewage network and treatment plants;	Source control, Stormwater network with storage and treatment	Best management practices of developed countries	Minimum contamination
			Stormwater network	Some developed countries and most of developing countries	Contamination of surface waters
		Sewage overflow (local treatment, septic tank or unregulated linking to the storm drainage system)	Stormwater network	Developing countries	Groundwater and surface waters contamination
			Street gutters	Developing and poor countries	Groundwater contamination, surface water and the streets. Potential disease proliferation
Combined	Medium to high	Sewage pipe network and treatment plants	Overflow above the design discharge to storage system with treatment	Old drainage system in developed countries, mainly in Europe	Minimum contamination
			Overflow above the design discharge to storage system without treatment	Old drainage system in developed and developing countries	High flood frequency in the street; high contamination during floods
			Overflow in the streets	Developing and poor countries	High urban flood frequency; contamination during floods
		Sewage network without treatment or treatment without network	Overflow in the streets	Developed and poor countries	Contamination in streets and surface waters; high urban flood frequency
Without system	Small/ medium and high	Without system	Streets	Poor neighbourhoods	Floods, contamination and diseases

2.4 Urbanization flow control and Urban Drainage Master Plan

Urban Drainage management in developing countries is mainly related to the lack of: flood control in the early stages of the urban development, institutional regulation, law enforcement, capacity building and public participation.

- *Planning urban flooding and storm drainage control:* planning flood control during the early stages of urban development has a small cost compared to this control when city is already developed. However, cities in developing countries usually lose their planning capacity during development and damage related to flooding nowadays represents one of the largest cost of this environment ;
- *Institutional regulation*: cities do not have any kind of regulation for stormwater control or technical department with can manage the problem;
- *Law enforcement*: to control the impact of urbanization on flow, it is necessary to create new regulations for urban developments, for instance, the limit of peak flow resulting from new developments. However often public undeveloped areas are invaded by squatters and developments within the city limits are implemented without formal approval by administration, how can this process be controlled? These difficulties are not an excuse for not passing the regulation and the Urban Drainage Master Plan.
- *Capacity building at all levels:* technical support for the municipality, architects, engineer and the public regarding urban flooding is one of the main requirements in order to improve management;
- *Public participation:* public participation on urban drainage management is not strong and the conflicts are mainly related to the lack of public commitment. Only during the major impacts and during events some public pressure is exerted on the municipal administration, which is usually forgotten after a while.

These issues, policies, climatic conditions related to the humid tropics and some strategies in the management of urban drainage in developing countries are discussed in chapter 6.

2.5 Diseases related to urban drainage

There are many diseases related to the lack of water management. In table 2.9 are presented some definitions related to this type of disease, based on the concepts of White et al (1972) and presented by Prost (1993):

- *Water borne diseases* are related to water quality and they depend on water for their transmission. A few years ago cholera spread through South America mainly to areas where the coverage of safe drinking water was low, such as Peru, the Amazon and the Northeast of Brazil;
- *Water-washed* diseases are related to hygienic practices which depends mainly on the social and health improvement of the community. They are related to skin, ear and eye infections;
- *Water-related* and *Water-based* diseases in which the agent uses water. Prost (1993) reported that any project which increases water surface results in the development of the Anopheles mosquito vectors of malaria and of one of the fresh water snail vectors of schistosomiasis. Another example is leptospirosis a disease that can develop after a flood due to rats urine.

In the Humid Tropics some of the human main disease related to water supply, sanitation and drainage are: diarrhea, cholera, malaria , dengue and leptospirosis. More than 50 communicable diseases are associated with poor sanitation, which results in millions of deaths,

mainly children. For instance, Bangladesh has twice the infant deaths in urban slums than in urban areas as a whole (Wright, 1997).

Tabel 2.9 Diseases associated with water (Prost, 1993)

Characteristics	Classification	Type
Water – borne: water acts as a passive vehicle for infectious agent	Bacterial	Salmonella (typhoid) Enterobacteria (E. coli) Campylobacter, Choleral Leptospirosis, etc
	Viral	Hepatitis A, Poliomyelitis Rotaviruses, Enteroviruses
	Parasitic	Amoebiasis, Giardasis, Intestinal protozoa, Balantidium coli
	Enteric	E.g. a proportion of diarrheas and gastroenteritis
Water – Washed: infections that decrease as result of increasing the volume water available	Skin	Scabies, Ringworm, ulcers, Pyodermitis
	Louse-Borne	Typhus and related fevers
	Treponematoses	Yaws, Bejel, Pinta
	Eye & Ear	Otitis, Conjunctivitis Trachoma
Water-Based: A necessary part of the life cycle of the infective agent takes place in an aquatic organism	Crustaceans	Guinea worm, paragonimiasis
	Fish	Diphyllobothriasis Anisakasis, Flukes
	Shellfish	Flukes, schistosomiasis
Water-Related: infections spread by insects that breed in water or bite near it	Mosquito	Malaria, Filariasis, Yellow fever, Dengue, hemorrhagic fever
	Tsetse flies	Trypanosomiasis (Sleeping sickness)
	Blackflies	Onchocerciasis

Esrey et al (1990) showed that each year there are: 875 million cases of diarrhea of which 4.6 million end in death, mostly children; 900 million cases of ascariasis with 20,000 deaths; and 500 million cases of trachoma with 8 million deaths.

Diarrhea is a disease much more close to the related water supply quality and sanitation. It is the main cause of children deaths in developing countries. Adequate water supply and sanitation decreases 55% the children mortality (World Resources, 1992).

Malaria is endemic in some countries and 40% of the word population has this disease, most of them Humid Tropics areas. Environmental conditions related to drainage which helps to spread malaria are: stagnant waters, deforestation, soil erosion and flooding.

Dengue is a disease related to warm climate and the disease spread depends on the mosquito which lives in clean and stagnant water that are in detained in homes (tires, vases, etc) during rainy season. On-site detention should be careful designed in this type of climate in order to not create an environment for this kind of disease. It has been a major disease in tropical cities such as Rio de Janeiro and Belo Horizonte in Brazil.

In 1990, diseases related to the lack of safe water were the source of 32,3 % of private hospital cases and 20% of the expenditures paid by the Brazilian Public Health Organisation. Chapter 6 of Agenda 21 (environmental Agenda for this century) includes the commitment to provide access to sanitary education, safe water access, eliminate sewage water to decrease wa-

ter-related diseases (cholera and Schistosomiasis) by 50 to 70 % until the year 2000 and infant diarrhoea by 25 to 50% .

Murray and Lopez (1990) presented a summary of the world burden of disease attributable to poor water supply, sanitation and personal domestic hygiene (table 2.10).

WHO (1988) presented the importance of control measures in disease prevention (table 2.11) . The main measures are related to water supply and sanitation in urban environments.

Table 2.10 Burden of disease attributable to poor water supply, sanitation and personal and domestic hygiene in 1990 (Murray and Lopez, 1996)

Region	Deaths	Percentage of all deaths
Established market economies	1,100	< 0,1
Formerly socialist economies of Europe	2,400	0.1
India	839,900	9.0
China	81,400	0,9
Other Asian countries and Islands	354,300	6,4
Latin American and the Caribbean	135,300	4,5
Middle Eastern Crescent	378,200	8,5
Developed regions	3,500	< 0,1
Developing regions	2,664,700	6,7
World	2,668,200	5,3

Table 2.11 Diseases related to water supply and sanitation control measures (WHO, 1988)[a]

Disease	Improvement in water Quality	Improvement in water supply /convenience	Personal and domestic Hygiene	Wastewater disposal /drainage	Excreta disposal	Food hygiene
Diarrhea						
Viral	M	H	H	-	M	M
Bacterial	H	H	H	-	M	H
Protozoal	L	H	H	-	M	M
Poliomyelitis and hepatitis A	L	H	H	-	M	M
Worm infections						
Ascaris,trichuris	L	L	L	L	H	M
Hook worm	L	L	L	-	H	-
Pinworm, dwarf Tapeworm	-	H	H	-	M	L
Other tapeworms	-	L	L	-	H	H
Schistosomiasis	L	L	-	L	H	-
Guinea-Worm	H	-	-	-	--	-
Other worms with aquatic hosts	-	-	-	-	M	H
Skin infections	-	H	H	-	-	-
Eye infections	L	H	H	L	L	-
Insect-transmitted diseases						
Malaria	-	-	-	L	-	-
Urban yellow fever, dengue	-	-	-	M	-	-
Bancroftian filariasis	-	-	-	H	H	-
Onchocerciasis	-	-	-	-	-	-

(a) Importance of control measures: H – high; M – Medium; L – low

2.6 Hydrologic data in urban areas

Hydrologic data in urban basins area usually not found in developing countries, and when there are some information it is mainly quantitative such as rainfall, level and discharge, but water quality and sediment records are rare. In Brazil, Tucci (1995) reported hydrologic data (rainfall and runoff) of 30 urban basins and Ide (1984) some records of water quality parameters from an urban basin in Porto Alegre.

This situation is mainly due to the following:

- The hydrologic networks are designed for major rivers and for water resources developments such as energy;
- Operational costs of an urban hydrologic network are very high due to environmental modification;
- Land use change is very rapid and requires a continuous update of the basin cover and drainage networks;
- Lack of funds for hydrologic records in urban areas;
- High cost for systematic water quality record;
- Urban drainage management is usually done by the counties administration which does not have funds and the capability to deal with hydrologic network;
- Urban basin flows present high variation in time which require appropriate equipment and special operational procedure to obtain rating curves and water quality sampling;
- Environmental changes in the basin and in the networks could closedown or move hydrologic gages.

Gladwell (1993) mentioned that the development of modern urban water management in developed countries, usually in temperate climates was preceded by a period of learning through historical records of the processes in the urban environment. Since there is no such information on Humid Tropics most of the solutions are based on overall observation or qualitative evaluation which increase the uncertainties of urban drainage management. The increase of information in these cities has been encouraged (Gladwell, 1991) but the reality is far from the desirable situation.

Most of the investments in developing countries have been from International funds which usually have short term goals. These projects usually do not invest in information which could give support to better projects and decisions.

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