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DOMESTIC POLLUTION

Chen Jining
Department of Environmental Science and Engineering, Tsinghua University, Beijing, China

Keywords: Municipal effluent, municipal wastes, disposal standards, municipal waste disposal and management, wastewater treatment technologies, municipal waste treatment technologies, wastewater reuse, waste reduction, reuse and recycle

Contents

Summary

Like industrial and agricultural activities, urban life can generate significant amounts of pollutants, and is one of the major pollution sources leading to the degradation of ecosystems. Adequate control of domestic pollution is thus required to safeguard the public health and urban life quality. Broadly, domestic pollution includes domestic sewage and solid wastes. Because of the similarity of human life, the characteristics of municipal pollution share the same pattern, though the generated amounts and compositions can be varied between different countries and regions.

Strategies for controlling domestic pollution have been quite successful in developed countries, yet are facing considerable economic constraints in developing countries. Over decades' application, both disposal standards and control technologies of domestic pollution have been well developed. Although there are a substantial number of technologies available for reducing pollution loads from domestic pollution, the emphasis is now largely shifting from "end-of-pipe" treatment to integrated management of urban environmental system. This has thereafter promoted the application of treated wastewater reuses and the application of the three "R" principles in municipal waste management, i.e., reduction, reuse and recycle before final disposal. Broadly, technologies for removing pollutants from wastewater mainly include physical, chemical, and biological treatment processes. For the control of solid wastes the mainstream technologies include landfill, incineration and composting.

1. Introduction

Like industrial and agricultural activities, urban life can generate significant amounts of pollutants, and is one of the major pollution sources leading to the degradation of ecosystems. Adequate control of domestic pollution is thus required to safeguard the public health and urban life quality. Broadly, domestic pollution includes domestic sewage and solid wastes. Because of the similarity of human's life, the characteristics of municipal pollution share the same pattern, though the generated amounts and compositions can be varied between different countries and regions.

Due to over decades' successful control in developed countries both disposal standards and technologies of domestic pollution have been well developed. It is fair to say that the effective control of domestic pollution has been the dominant factor for improving the environmental quality in developed countries, and is of major implication to the environmental management in developing countries. This article is directed towards the discussion of domestic wastewater and solid wastes. It began with the summary of the characteristics of domestic wastewater and solid wastes. The focuses are then turned to discussions of disposal of domestic wastewater and wastes respectively. Due to the importance of reclaimed wastewater as an alternative water resource, reuses of domestic wastewater are also presented herein.

2. Characteristics of Domestic Wastewater

Domestic wastewater is a combination of effluents from residences, commercial buildings, institutions and similar facilities. The non-consumptive portion of water used in an area constitutes most of the domestic wastewater. It is generated from kitchen, bathroom, laundry, lavatories, toilets, garbage grinders, dishwashers, washing machines, and water softeners. As a by-product of life and living processes, its characteristics are strongly associated with the life-style and population of the served area, and the time of the year.

In general, variations of both domestic wastewater flow and composition follow hourly, daily, weekly and monthly lifestyle patterns of the serviced residential customers. Figure 1 presents a typical hourly variation of wastewater flow and pollutants over a 24-h period. The hourly peak flow rate is often 50 percent higher than the average twenty-four hour rate, and the maximum hourly load can be at least twice the average hourly load. Although these numbers will vary with locality, such a pattern is not unusual since the daily cycle of human life is more or less the same over the world. But as the sewer system and the service population expand, the impact of domestic population becomes less pronounced in terms of peak to average and minimum ratios of both quantity and pollutant loads.

Both the flow and composition of domestic wastewater can be predicted reasonably well. They are usually quantified either through direct measurements or by model estimation. Public water-supply records can also be applied for estimating flow rate. It is important to note that some water is not converted into sewage, however, due to evaporation, transpiration, and consumption. In most cases, this water is lost via pipe leakage, street washing, lawn sprinkling, and fire fighting. Studies revealed that, leaving aside infiltration of groundwater, approximately 20–40 percent of the total quantity of water supplied in a residential area is consumed, and the remaining 60–80 percent is discharged to the sewer as municipal effluent.

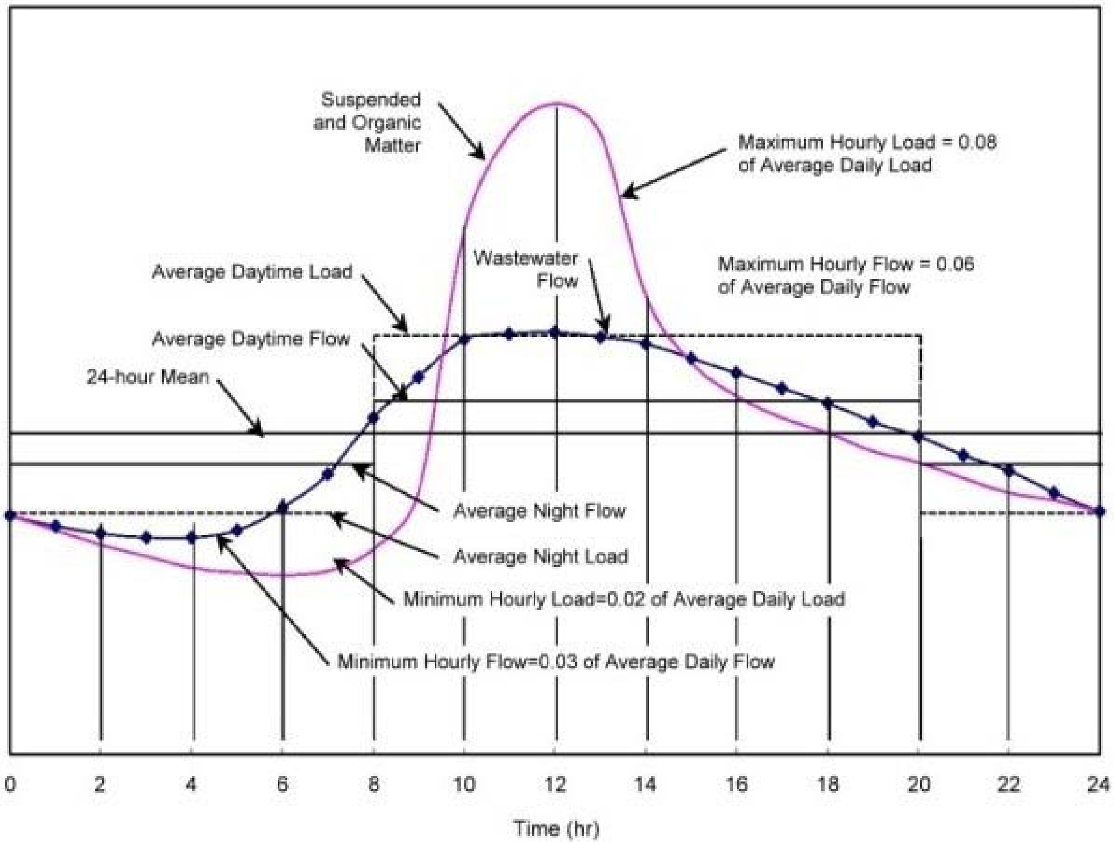

Figure 1: The typical hourly variation of Municipal wastewater flow

When modeling domestic wastewater flow rates and pollution loads, two elements are crucial: the population and the per capita sewage contribution. Population can be reliably estimated in most areas except in holiday resorts or rapidly urbanizing cities. Per capita sewage flow rates and loads, however, show wide variations across different areas. The flow rate, for instance, is less than 200 l/day in France, the UK, and Germany, but can be more than 400 l/day in North America. Variations are due not only to location, climate, community size, water pricing, and water-metering coverage rates, but also to such factors as living standards and lifestyles, water infiltration from collection pipes, and the extent of in-house water re-use. With increasing use of such modern household appliances as garbage grinders, dishwashers, and washing machines, there has been a clear upward trend in domestic water use, though this tendency depends to a large extent on the availability of water in the given community. Plenty of literature is available for considering flow rates and concentrations of different water use components in detail, as presented in Tables 1–4.

In general, the major concerned pollutants of domestic wastewater include suspended solids, organic matter measured as BOD5, COD, or TOC, microorganisms, pathogens, nutrients, coliform bacteria and refractory organics. Their major local effects are the epidemical potential to public health, the deterioration of water quality in the receiving water body, the restrictions on the possible uses of the water, and the urban life quality. Nowadays, the worst problems are posed by organic matter, which can cause depletion of dissolved oxygen and the development of septic conditions. This may kill fish, and lead to the loss of ecological and aesthetic value in a watercourse. Pathogens, indicated by coliform bacteria, used to be extremely hazardous to public health, since they are capable of causing diseases such as typhoid and paratyphoid fever, dysentery, diarrhea, and cholera. They are becoming less concern due to the significant improvement of urban infrastructures, but are still a major problem in less developed countries. Concern about nutrients is increasing and is largely due to the manner in which they increase the growth rate of aquatic plants and algae in slow-moving waters. Excessive growth of plants (particularly unicellular phytoplankton) is called eutrophication. Eutrophication may interfere with the use of water by clogging water-intake pipes, changing the taste and color of water, and causing the rapid buildup and decay of organic matters, and eventual loss of fish and other aquatic species.

Types of establishment	Liters per person or unit per day
Small dwellings and cottage with seasonal occupancy	190
Single family dwellings	285
Multiple-family dwellings (apartments)	227
Rooming houses	150
Boarding houses	190
Additional kitchen wastes for nonresident boarders	38
Hotels without private baths	190
Hotels with private baths (2 persons per room)	227
Restaurants (toilet and kitchen wastes per patron)	26-38
Restaurants (kitchen wastes per meal served)	9-11
Additional for bars and cocktail lounges	8
Tourist camps or trailer parks with central bathhouse	132
Tourist courts or mobile home parks with individual bath units	190
Resort camps (night and day) with limited plumbing	190
Luxury camps	380-570
Work or construction camps (semi-permanent)	190
Day camps (no meal served)	57
Day schools without cafeterias, gymnasiums or showers	57
Day schools with cafeterias, but no gymnasiums or showers	75
Day schools with cafeterias, gymnasiums or showers	95
Boarding schools	285-380
Day workers at schools and offices (per shift)	57
Hospitals	570-945
Institutions other than hospitals	285-475
Factories per person per shift exclusive of industrial wastes	57-132
Picnic parks (toilet wastes only, per pick-nicker)	19
Picnic parks with bathhouses, showers and flush toilets	38
Swimming pools and bathhouses	38

Luxury residences and estates	380-570
Country clubs (per resident member)	380
Country clubs (per nonresident member present)	95
Motels (per bed space)	150
Motels with bath, toilet and kitchen wastes	190
Drive-in theaters (per car space)	19
Movie theaters (per auditorium seat)	19
Airports (per passenger)	11-19
Self-service laundries (per wash, i.e., per customer)	190
Stores (per toilet room)	1500
Service stations (per vehicle served)	38

Table 1: Sewage flow rates in commercial facilities

Device	Range of flow
Automatic home laundry machine	110-200 l/load
Automatic home-type dishwasher	15-30 l/load
Automatic home-type washing machine	130-200
Bathtub	90-110 l/use
Continuous-flowing drinking fountain	4-5 l/min
Dishwashing machine, commercial: [a]	
Conveyor type, at 100 kN/m2	15-25 l/min
Stationary rack type, at 100 kN/m2	25-35 l/min
Fire hose, 38mm, 13mm nozzle, 20m head	140-160 l/min
Garbage-disposal unit, home-type	6000-7500 l/wk
Garbage grinder, home-type	4-8 l/person d
Garden hose, 16mm, 8m head	10-12 l/min
Garden hose, 19mm, 8m head	16-20 l/min
Lawn sprinkler	6-8 l/min
Lawn sprinkler, 280m2 lawn, 25mm/wk	6000-7500 l/wk
Shower head, 16mm, 8m head	90-110 l/use
Washbasin	4-8 l/use
Water closet, flush valve, 170 kN/m2	90-110 l/min
Water closet, tank	15-25 l/use

[a] Does not include water to fill wash tank

Table 2: Typical rates of water use for various devices

Pollutants	Concentrations (mg/l except setteable solids)	
	Range	Average
Solids, total	350-1200	720
Dissolved, total	250-850	500
Fixed	145-525	300
Volatile	105-325	200
Suspended, total	100-350	220
Fixed	20-75	55
Volatile	80-275	165
Settleable solids, ml/l	5-20	10
BOD, 5-day 20°C	110-400	220
TOC	80-290	160

COD	250-1000	500
Nitrogen (total as N)	20-85	40
Organic	8-35	15
Free ammonia	12-50	25
Nitrites	0	0
Nitrates	0	0
Phosphorus (total as P)	4-15	8
Organic	1-5	3
Inorganic	3-10	5
Chlorides	30-100	50
Alkalinity (as $CaCO_3$)	50-200	100
Oil and grease	50-150	100

[a] Adapted from Tchobanoglous (1979).

Table 3: Typical major pollutant composition of municipal wastewater

Constitutes	Ranges (mg/l)
Anions:	
Bicarbonate (HCO_3)	50-100
Carbonate (CO_3)	0-10
Chloride (Cl)	20-50[b]
Nitrate (NO_3)	20-40
Phosphate (PO_4)	20-40
Sulfate (SO_4)	15-30
Cations:	
Calcium (Ca)	15-40[c]
Magnesium (Mg)	15-40[c]
Potassium (K)	7-15
Sodium (Na)	40-70
Other data:	
Aluminum (Al)	0.1-0.2
Boron (B)	0.1-0.4
Fluoride (F)	
Iron (Fe)	0.2-0.4
Manganese (Mn)	0.2-0.4
Silica (SiO_2)	2-10
Total alkalinity	100-150[c]
Total dissolved solids (TDS)	150-400

[a] Adapted from Tchobanoglous (1979).
[b] Excluding the addition from domestic water softeners
[c] Reported as $CaCO_3$

Table 4: Typical mineral concentrations in municipal wastewater

3. Characteristics of Domestic Solid Wastes

Domestic solid wastes are produced from residential, commercial, and institutional establishments. Different from wastewater, solid wastes are mostly quantified by weight rather than volume because the use of volume can often be misleading. A cubic meter of loose wastes is a wholly different quantity from a cubic meter of compacted wastes in a collection vehicle. Yet on occasion when designing the capacity of landfills, volume and weight are equally important.

As with domestic wastewater, the composition and amount of domestic wastes are subject to local living standards, lifestyles and energy structures. Developed countries tend to generate more municipal waste per capita than developing countries. A typical amount for the former is 1.2–1.8 kg per person per day, while the latter may be as low as 0.3–0.6 kg per person per day.

The amount of domestic wastes varies daily, weekly, monthly and seasonally, often with peaks during holiday season and spring housecleaning days. During summer time when both vegetables and fruits are abundant, the amount of solid wastes may also be conspicuously large since food and other organism rot easily. It is generally noted, however, that the weekly average amount of domestic wastes is not more than 15% of the year's average although it will be higher than 25% in special holiday time. With increasing environmental concern, the generated amount of domestic wastes could be reduced considerably through source reduction and reused programme or regulations. Efforts on classification also help to reduce domestic wastes.

Waste Category	Percent by Weight	
	Range	Typical
Residential and Commercial, excluding special and hazardous wastes	50-75	62.0
Special	3-12	5.0
Hazardous	0.01-1.0	0.1
Institutional	3-5	3.4
Construction and Demolition	8-20	14.0
Municipal Services		
Street and Alley Cleanings	2-5	3.8
Tree and Landscaping	2-5	3.0
Parks and Recreational Areas	1.5-3	2.0
Catch Basin	0.5-1.2	0.7
Treatment Plant Sludge	3-8	6.0
Total		100.0

Table 5: Typical distribution of components of municipal solid wastes

Domestic wastes can be divided into organic and inorganic solids. The organic fraction of waste consists primarily of materials such as food wastes, papers, cardboard, plastics, textiles, rubber, leather, wood, and yard wastes; the inorganic fraction consists mainly of items such as glass, crockery, tin cans, aluminum, ferrous metals and dirt. Special domestic wastes may also include bulky items, consumer electronics, used batteries, paints, waste oils, and tires. These wastes are usually handled separately from residential and commercial wastes. In addition other community wastes, resulting from the operation and maintenance of municipal facilities, and the provision of municipal services, are also of concern. They include street sweepings, road litter, solid wastes from municipal litter containers, landscape and tree trimmings, dead animals, and abandoned vehicles. The origins of solid wastes from a typical community are presented in Table 5. Table 6 summarizes the component distribution of residential domestic solid waste, excluding recycled materials. In general, the residential and commercial fractions usually represent 50–75 percent of total domestic solid waste, subject to:

- The extent of construction and demolition activities
- The level of the municipal services provided
- The types of waste and wastewater treatment processing used.

Component	Low-income Countries	Middle-income Countries	Upper-income Countries
Organic			
Food Wastes	40-85	20-65	6-30
Paper	1- 10	8-30	20-45
Cardboard	---	---	5-15
Plastics	1-5	2-6	2-8
Textiles	1-5	2-10	2-6
Rubber	1-5	1-4	0-2
Leather	---	---	0-2
Yard Wastes	5	1-10	10-20
Wood	--	--	1-4
Misc. Organic	---	---	---
Inorganic			
Glass	1-10	1-10	4-12
Tin Cans	---	---	2-8
Aluminum	5	1-5	0-1
Other metal	---	---	1-4
Dirt, Ash, etc	1-40	1-30	0-10

* Adapted from 'Integrated Solid Waste Management', Geoge Tchobanoglous, Hilary Theisen, Samuel Vigil, Mcgraw-Hill, Inc. 1993

Table 6: Typical component distribution of residential municipal solid waste, excluding recycled materials

Reasonable estimation of solid waste amounts and composition is important in domestic waste management. It is not only required for assessing environmental impacts of wastes, but also for evaluating the potential quantity of re-useable energy, for designing waste collection routes, materials recovery and disposal facilities. Various models of domestic waste projection have been developed since 1970s, and most are based on the estimation of the amount of wastes per capita. For instance, there have been various established relationships to link the domestic waste per capita to the Gross National Production (GNP), from which the amount of domestic waste could then be estimated for different economic levels. Other detailed models include the consideration of living level, geographic location, social energy resources structure and people's diet habit based on a large number of investigation data.

4. Disposal Control of Domestic Wastewater

Disposal of wastewater effluent can be in different ways including dilution in receiving waters, discharge on land and seepage into the ground. Disposal to surface water bodies, such as rivers, lakes, estuaries and oceans, is by far the most common approach. Effluent disposal standards are developed to control those wastewater discharges that may cause harmful impacts to human health, drinking water resources and aquatic ecological systems, or may cause damage to amenities or interference with other legitimate uses of water. In parallel, receiving water quality criteria are also established to link water uses and the necessary water quality control objectives, by which the discharged effluents are regulated so as not to exceed the assimilative capacity of the receiving waters.

Domestic wastewater disposal standards are developed in terms of either water quality criteria, or technology-based limits or both. Often effluent disposal guidelines and directives, rather than standards, are applied since the self-purification capacity of the receiving water is highly subject to the local hydrological and physic-chemical conditions (e.g., the flow rates, the oxygen content and the aeration ability), and the temporal and spatial variability of the discharged pollutant loads. It is not surprised, thereafter, that different countries may have different systems and standards to implement wastewater disposal standards. There are, however, common pollutants considered in all domestic disposal regulations. The major conventional ones include solids, organic matters, bacteria and nutrients. Often nutrients are specially required in sensitive water-bodies liable for eutrophication. Tables 7 and 8 listed the required treatment levels of domestic pollution according to EC water directives.

Parameters	Concentration	Minimum Percentage of Reduction (1)
Biochemical oxygen demand (BOD_5 at 20 °C) without nitrification (2)	25 mg/l	70-90 40 under Article 4 (2)
Chemical oxygen demand (COD)	125 mg/l	75
Total suspended solids	35 mg/l 35 under Article 4 (2) (more than 10000 p.e.) 60 under Article 4 (2) (2000-10000 p.e.)	90 (3) 90 under Article 4 (2) (more than 10000 p.e.) 70 under Article 4 (2) (2000-10000 p.e.)

Note: (1) Reduction in relation to the load of the influent. (2) The parameter can be replaced by another parameter, i.e., the total organic carbon (TOC) or total oxygen demand (TOD) if a relationship can be established between BOD_5 and the substitute parameter. (3) This requirement is optional. Analyses concerning discharges from lagoon shall be carried out on filtered samples; however, the concentration of total suspended solids in unfiltered water samples shall not exceed 150 mg/l.

Table 7: Requirements for discharges from all urban wastewater treatment plants in the EC Directive

Although municipal wastewater treatment plants (MWTPs) mainly receive domestic sewage from residential and commercial customers, they may also accept industrial wastewater. If MWTPs regularly receive toxic chemicals released by the industrial facilities, MWTP effluent limits could include limits for those pollutants to protect the water quality of the receiving streams. However, logically since it is much easier and effective to control the sources of pollutants, the local permitting authority should issue pre-treatment limits to the industries. The main objective of the pre-treatment is to ensure a MWTP's effluent limits can be met without any interference from industries. An effective pre-treatment program can help reduce the levels of toxic pollutants in MWTP effluent and sludge.

For MWTPs, the treatment technologies include typically physical separation and settling (e.g., screening, grit removal and primary settling), biological treatment (e.g., trickling filters and activated sludge), and disinfection (e.g., chlorination, UV and ozone). These processes constitute the well-known primary, secondary and advanced treatment. Primary treatment is a simple gravity process, through which 25%-30% of BOD can be removed by solid separation and settling. Secondary treatment is usually a biological process, from which 90% of BOD can be removed; while the advanced treatment can remove 99% of BOD.

Parameters	Concentration	Minimum Percentage of Reduction (1)
Total phosphorus	2 mg/l (10 000 - 100 000 p. e.) 1 mg/l (more than 100 000 p. e.)	80
Total nitrogen (2)	15 mg/l (10 000 - 100 000 p. e.) 10 mg/l (more than 100 000 p. e.) (3)	70-80

Note: (1) Reduction in relation to the load of the influent. (2) Total nitrogen is the sum of total Kjeldahl-nitrogen (organic N + NH_3), nitrate (NO_3)-nitrogen and nitrite (NO_2)-nitrogen. (3) Alternatively, the daily average must not exceed 20 mg/l. This requirement refers to a water temperature of 12° C or more during the operation of the biological reactor of the wastewater treatment plant. As a substitute for the condition concerning the temperature, it is possible to apply a limited time of operation, which takes into account the regional climatic conditions. This alternative applies if it can be shown that paragraph 1 of Annex I.D is fulfilled (which have been adapted by 98/15/EEC).

Table 8: Requirements for discharges from urban wastewater treatment plants to sensitive areas that are subject to eutrophication

Pollutant	Effluent Limitations		
		Adjustment	
BOD_5	30mg/l 45mg/l 85% removal	45mg/l 65mg/l 65% removal	Maximum 30-day average Maximum 7-day average Minimum30-day average
$CBOD_5$	25mg/l 40mg/l 85% removal	45mg/l 65mg/l 65% removal	Maximum 30-day average Maximum 7-day average Minimum30-day average
SS	30mg/l 45mg/l 85% removal	45mg/l 65mg/l 65% removal	Maximum 30-day average Maximum 7-day average Minimum30-day average
PH	6.0-9.0	6.0-9.0	Range

Table 9: The required effluent quality for secondary treatment

Presently in developed countries, domestic dischargers were mostly required to achieve the secondary or its equivalent treatment levels. Table 9 shows the required effluent quality for secondary treatment in the US NPDES. But it requires that adjustments be made for the effluents from trickling filters and waste stabilization ponds. And exceptions to these requirements may be granted for facilities which discharge to the ocean.

Generally, strict regulations of wastewater disposal over years have led developed countries to a stage with only limited conventional water pollution problems, and effluent standards and regulations are currently designed towards the control of micro-pollutants, the impact of pollutants in sensitive areas or the pollution caused by the drainage of storm water. Developing countries, however, are under a constant and significant pressure to follow the international trends of frequently lowering the limit concentrations of the standards, meanwhile being unable to reverse the continuous trend of environmental degradation.

5. Reuse of Domestic Wastewater

Different from being regarded as a source of pollution, treated domestic wastewater can be an alternative water resource in water shortage areas through various benefit reuses. However, a successful application depends on a number of factors, of which quantity and quality must deserve the most attention. The former deals with how reliable and dependable the source is. The latter concerns how safe the reused water would be to human beings and the relevant eco-system, in particular for long-term application. In general, municipal wastewater reuse can be classified under direct or indirect reuse. Direct reuse requires distribution systems to deliver treated wastewater to the users. It is planned, deliberate, or intentional use of treated wastewater for some beneficial purposes. Direct reuse of treated wastewater for drinking water, however, is not a viable option at this time due to health risk concerns. Indirect reuse refers to the use of treated wastewater after its return to natural water sources (i.e. river, lake and aquifer) for purification and dilution.

Though being strongly associated with locality, treated sewage is mostly applied for the following usages,

- Agricultural irrigation;
- Industrial reuse;
- Groundwater recharge;
- Urban application;
- Augmentation of potable supplies; and
- Recreational and habitat restoration/enhancement.

The potential for any of these applications is subject to the control of pathogens, biodegradable and refractory pollutants, heavy metals and other toxic organics. Since municipal wastewater treatment plants may receive toxic chemicals from industries, effective pretreatment and pollution prevention programs are absolutely necessary prior to any potential reuse application is considered. Depending on the specific reuse application, a high level of treatment provided by the municipal wastewater treatment facilities may be required in order to protect human health and the environment. These concerns thus necessitate the formation of criteria, standards and guidelines that are appropriate for the users or consumers of this water, which again is manifested via its physical, chemical, biological and even radiological characteristics.

Due to the complexity of different wastewater sources and different reuse applications, however, there are no national standards for wastewater reuse. Currently, wastewater reuse is mainly managed via regulations and guidelines. In the USA, wastewater reuse is regulated and enforced by state agencies, not federal government. These state agencies issue reuse permits specifying conditions, requirements and limitations, as well as initiate enforcement actions for permit violations. The U.S. Environmental Protection Agency (EPA) published reuse guidelines in 1992, which has been used in the development of water reuse regulations by many state agencies. According to EPA, the guidelines are not intended to be used as standards. An updated guidelines manual will soon be published by EPA to reflect technical advancements and institutional developments since 1992.

At present, the largest volumes of treated wastewater are used for agricultural irrigation followed by landscape irrigation, domestic application and industrial reuse. In USA, for instance, 34 and 63 percent of wastewater reuse is for agriculture in Florida and California respectively. In recent years, however, other applications have seen a rapid increase by taking reused sewage as an integrated part of national/regional water resources.

Although wide practices have shown that the use of treated sewage for agricultural irrigation is of major advantages, the constraints and risks cannot be ignored, in particular for the potential transmission of diseases. Other concerned parameters include salinity, exchangeable ions (Na, Ca, and Mg), boron, and trace metals (Cd, Cr, Cu, Hg, Ni, Mo, Pb, and Zn). For safety reason, wastewater reuse guidelines and regulations for agricultural irrigation are thus developed in terms of the crops and the potential for public contact. The crops are categorized into restricted and unrestricted irrigations, subject to whether the crops are ingested by humans and cattle, as presented in the WHO Guidelines. In the restricted irrigation, the requirements for reused sewage quality can vary widely, ranging from acceptance of untreated sewage to secondary treaded effluents. And in the unrestricted irrigation, the standards are, to a large extend, subject to the risk assessment method adopted, in particular for the microbiological quality. Beside regulations, good practices and application procedures are essential to avoid disease transmission and protect field workers.

In the context of industrial application, the major wastewater reuse is for cooling water including tower makeup water, one-through cooling water and low-pressure boiler feed water. Note that cooling water is widely used in many industrial processes, such as electric power generation stations, oil refining, and other types of manufacturing plants. In general, however, there are four major problems associated with the water quality in the operation of industrial cooling tower, i.e., metallic corrosion, biological growths, scaling and fouling. These problems can occur no matter whether reclaimed wastewater or freshwater is used, but the severity of the former is relatively higher than the latter.

In addition to direct potable supply, groundwater recharge is required to have the strictest risk control, thus involves the most expensive water reuse utilities. Highly subject to local geo-hydrological conditions, groundwater recharge is mostly based on a case-by-case approval procedure, with different quality standards for surface spreading and direct injection. So far, the most successful application of groundwater recharge is in California, whose recharged water is at an amount up to 150×106m3/a, involved several important projects and a significant potential use in the Los Angeles area.

In recent years domestic wastewater reuse has been one of the fastest growing reuse types worldwide and has shown substantial potential to replace non-drinking urban water uses. Their wide applications may include landscape irrigation, car washing, window cleaning, toilet flushing, dust control and fire protection etc. In addition to quality and quantity, presently the major concern of domestic application of treated sewage is the costs. As a separate distribution system is required for transportation of the reclaimed water, it poses a significant economic challenge, in particular for cities in which the infrastructure development has been completed.

Another increasing application of wastewater reuse is recreation, habitat restoration and enhancement including augmentation of the flows of rivers, lakes, ponds and marsh, creation or maintenance of artificial aquatic environments such as fisheries and so on. Criteria of recreational reuse depend upon whether the reuses are passive and active. In particular of the concerned pollutants, the pathogen concentrations are subject to the level of human contact. The avoidance of eutrophication is another major concern due to excessive algae growth caused by nutrients present in wastewater. To limit the rate of algae production, the controlled nutrients must be reduced to the level where it inhibits algae growth. Parameters such as temperature, pH, micro-organics including bacteria and viruses, metals are also concerned in certain applications such as swimming and growth of shellfish.

6. Management of Domestic Wastes

It is well known that management of domestic wastes follows widely the three "R" principles, i.e., reduction, reuse and recycle before final disposal. Reduction is to reduce wastes that have to be collected and disposed of by solid waste authorities to prevent recyclable and compostable organic matters from appending to final waste streams. Waste reuse is to use an unbroken "waste" product for the same or a different purpose. If the original product has been transformed into secondary resources for manufacturing new products, the material recovery process is then called as recycle. Waste reduction can be achieved by two ways, i.e., source reduction and source separation. The former is to reduce solid wastes at the point of generation and is the most active and economic way to decrease domestic waste stream. The latter is to keep different categories of recyclable and organic matters separate at source, i.e., at the point of generation, to facilitate reuse, recycling, and composting.

Action for waste reduction and recovery can take place many routes and the important ones include (i) reducing materials uses in products or packaging; (ii) requiring producers to accept responsibility for waste recovery from their products; and (iii) reducing production and application of perishable consumer goods; (iv) collection of organics for large-scale composting; (v) promotion of backyard composting; and (vi) public education to sustain participation in all aspects of waste reduction.

International trade in recyclable wastes is growing in the last decade across regions and countries. The major trading wastes include paper, board paper, plastics, clothing, old machinery and construction materials. This creates both a better opportunity to material recovery and a potential threat transfer of environmental risks. Some governments and environmentalists have thus objected to imports of mixed plastics and containers that have not been thoroughly cleaned to prevent the deceptive or inadvertent import of hazardous and contaminated wastes. Imports, even of clean recyclable wastes, may have adverse economic impacts in developing countries. Some restrictions have been designed to protect some industries, such as clothing manufacturing by banning the import of used clothes.

Waste collection and transfer is an important part of domestic waste management. It is the largest cost element in most wastes disposal systems, accounting for 60-70% of costs in industrialized countries and 70-90% of costs in developing and transition countries. Its failure or inadequacy can lead to threats to environment and public health. The main elements have to be considered in collection include the operational plan, container, vehicle and transfer station. Two types of collection process are in application, i.e., compound collection and classified collection. For the former, domestic wastes are collected without any pre-treatment. It is easier to run, with low cost, but is hard to be regenerated. To the contrary, classified collection is of significant advantages for minimization and treatment domestic wastes.

Waste transfer refers to the movement of waste or materials from the primary collection vehicle to a secondary, generally larger and more efficient, transport vehicle. While virtually all wastes systems have collection, not all include transfer. The spot of transfer is referred to as a transfer station. Primary collection vehicles bring their waste to a transfer station and dump it. It is then transferred, with or without compaction, to other vehicles for a longer haul to a disposal site. Transfer, which may include a short storage period, also provides a point of access to the waste or materials stream and an opportunity to remove certain materials or perform processing such as shredding, compacting, screening, wetting, or drying.

Domestic wastes are mostly treated or disposal through landfill, incineration or compost. Selection of a disposal approach is subject to many factors including costs, technical feasibility, social acceptability, natural conditions and the characteristics of domestic wastes. Generally, the cost of incineration for both facilities construction and operation is much higher than landfill. Composting, though being less costly, relies strongly on the marketing demand for composting products. Different from wastewater treatment, selection of disposal system of solid wastes is more sensible to society and nature. For example, incineration would intimidate air quality by dust and chemicals primarily while landfill and composting contaminate groundwater with organic matters, heavy metals and air with stench, infection and gas.

Because a large volume of unusable residue is produced by incineration and composting of domestic wastes, landfill has become an exclusive feasible and universal way for the final disposal of domestic wastes. In most countries including those with very high population density, about 70% - 90% of domestic wastes are disposed by landfill directly. Presently there are three categories of landfills in operation, i.e., open dumps, controlled dumps and sanitary landfills. Open dumps pose significant risks to human health and the environment. Since controlled dumps are labour-intensive, they are mostly applied in regions where capital is severely limited, labour is available at low cost, and there is a shortage of expertise and infrastructure to service a highly mechanized facility. Such conditions prevail in many developing countries. Differently, a sanitary landfill can provide effective disposal of domestic wastes in accordance with appropriate local health and environmental standards, and thus should be the targeted option of waste disposal.

Incineration is a thermal conversion technology and its primary benefit is a substantial reduction of weight (up to 75%) and volume (up to 90%) of solid waste. In addition, incineration can break down hazardous and non-metallic organic wastes, and destroy bacteria and viruses. In considering the incineration option, however, decision-makers must weigh its benefits against the significant capital and operating costs, potential environmental impacts, and technical difficulties of operating an incinerator. Attention should also be paid to the composition of domestic wastes, as it is difficult to incinerate those wastes with high moisture and low energy content, which are widely present in developing countries.

Composting is a process of biological decomposition and stabilization of organic substrates. The production from composting is called compost. Use of compost as a soil conditioner, a fertilizer, or a growth medium has significant environmental benefits. In addition to returning nutrients to soil and thus permitting the reduction of artificial fertilizers, compost can also be used as daily cover at landfill sites to replace clay or synthetic materials. Currently there are two kinds of composting processes, i.e., aerobic and anaerobic composting, both of which can reduce 50-70 percent of domestic wastes in weight. Composting operation was developed unfavorably in history. The reasons for that include high operation and management costs, high transportation costs, poor quality product as a result of poor pre-sorting, poor understanding of the composting process, and competition from chemical fertilizers on market. In many urban places, collection systems are too unreliable for urban authorities to consider running composting facilities efficiently.

7. Conclusions

Broadly, domestic pollution includes domestic wastewater and solid wastes. Because of the similarity of human's life, the characteristics of domestic pollution share the same pattern, though the generated amounts and compositions can be varied between different countries and regions. In general, the environmental impacts, mostly on receiving water-bodies, from domestic sewage are direct and immediate. It is thus not surprised that there are well-formatted disposal and water quality standards for managing domestic wastewater pollutions. The controlled pollutants are also well documented and the major ones include organic matters, nutrients and pathogens. Domestic wastes, however, are more complicated in composition and are mostly measured by weight or volume, and thus are controlled through a waste management plan, which includes source separation, collection, transfer and final treatment and disposal.

Although being the major contribution to the deterioration of environmental quality, the control of domestic sewage and wastes has been one of the most successful management of environmental pollutions in developed countries in the last several decades. There is no doubt that those experiences as well as the developed technologies are mostly applicable to developing countries, though developing countries are facing considerable economic constraints. Given that traditional gross pollutants (for example, organic matters and excess nutrients) are largely under control in developed countries, achieving reliable and steady environmental quality has been the focus of domestic pollution. It is increasingly clear that individual or random discharges (arising from spills, storm runoff, and other events) may lead to environmental impacts as significant as those from gross pollution, yet the costs of prevention and control can be prohibitively high. Newly-recognized pollutants, such as dioxin and other specific toxic substances, are also becoming a significant challenge to effective pollution control.

Glossary

BOD:	Biological Oxygen Demand.
COD:	Chemical Oxygen Demand.
TOC:	Total Organic Carbon
GNP:	Gross National Production
MWTPs:	Municipal Wastewater Treatment Plants
WHO:	World Health Organization.

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Biographical Sketch

Jining Chen is Professor and Head of the Department of Environmental Science and Engineering at Tsinghua University, Beijing, Peoples' Republic of China. Professor Chen holds an honorary first degree in Environmental Engineering from Tsinghua University (1986) and a Ph.D. in Environmental System Analysis from Imperial College, London (1993). His current research interests include environmental systems analysis; identification of environmental models; water resources and environmental policy; integrated river basin planning and management; non-point source pollution control; and sustainable cities. He is presently a member of the governing boards of several Chinese technical associations, including the Chinese Environmental Engineering Society Deputy, of which he is Deputy Chairman. He is also a member of the scientific committees of several environmental journals.