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Wastewater reclamation and reuse in Eureau countries

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Abstract

Eureau is the Union of most National Associations of Water Suppliers and Wastewater Services in Europe. Most northern Eureau countries have abundant water resources. There, the need for extra supply through the reuse of treated wastewater is not a priority, but the protection of the receiving environment is considered important. The situation is different in the southern Eureau countries, where the additional resources brought by wastewater reuse can bring significant advantages to agriculture (e.g. crop irrigation) and tourism (e.g. golf course irrigation). There, wastewater is reused but under very diverse regulatory environments. Therefore, considering its various potential benefits (protection of water resources, prevention of coastal pollution, recovery of nutrients for agriculture, augmentation of river flow, savings in wastewater treatment, groundwater recharge, and sustainability of water resource management, etc.), wastewater reclamation and reuse can be applied to the advantage of both northern and southern Eureau countries. In order to take advantage of its full potential, Eureau would like to become involved in setting up international best practices and guidelines related to the reuse of treated wastewater. Such criteria and/or guidelines should contribute to a better management of water resources, a better protection of public health and of the environment and to a more sustainable development. Reclaimed wastewater is a reliable source of water that must be taken into account in formulating a sustainable water policy. To encourage wastewater reclamation and reuse in all Eureau countries and to establish its safe practice, European guidelines for most applications must be developed.

1. The nature and structure of Eureau

Eureau is the Union of National Associations of Water Suppliers and Waste Water Services from countries within the EU and the EFTA. It was founded in 1975 as a non-profit-making

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association by the national associations of water suppliers from the six countries then forming the European Community. Today, Eureau has 20 full members and seven observer members, all national associations of water suppliers and/or waste water services. Seventeen come from European Union countries — Austria, Belgium, Denmark, Finland, France, Ireland, Italy, Germany, Greece, Luxembourg, Netherlands, Portugal, Spain, Sweden and the United Kingdom. Three come from the European Free Trade Association: Iceland, Norway and Switzerland. Additionally, Bulgaria, Croatia, Cyprus, Estonia, Hungary, Poland, and Romania are observer members.

Eureau represents the water and sewerage service industry for about 400 million customers in Europe. In addition to Eureau's central structure (see Fig. 1), four Standing Commissions address drinking water (EU1), wastewater (EU2), legislation and economics (EU3) and standardisation and certification (EU4). A special Working Group on Wastewater Reclamation and Reuse has also been established with members of the first two commissions.

The objectives of Eureau — as defined in its statutes — is to represent the common interests of its member associations to the Community organisations dealing with Community legislation and European standards relevant to water supply and wastewater. Although Eureau has no power of decision, its representative nature and its scientific, technical and managerial expertise make the organisation an appropriate body to be consulted and recognized by Community organisations. Eureau's scientific, technical and managerial expertise aim at bringing it recognition from European institutions. It seeks to put its members' expertise and knowledge at the disposal of the Community organisations so that they may be taken into account in any new legislation affecting the water industry ensuring that consumers' interests are properly considered. Eureau's remit is twofold: to review and discuss prospective legislation and standards to give Community organisations the collective view of the water industry across Europe and to analyse existing legislation so that, at the time of revision, a sensible view can be put forward, balancing the politically desirable with the technically achievable. As the protection of water resources is of utmost importance for Eureau, it supports the Community Programme of policy and action in relation to the environment and sustainable development.

This paper summarizes the Eureau experience and investigation on wastewater reclamation and reuse practices of various member countries. In addition, water resources status, legislation and guidelines on wastewater reuse at European level and a variety of approaches in regulating wastewater reuse are briefly presented.

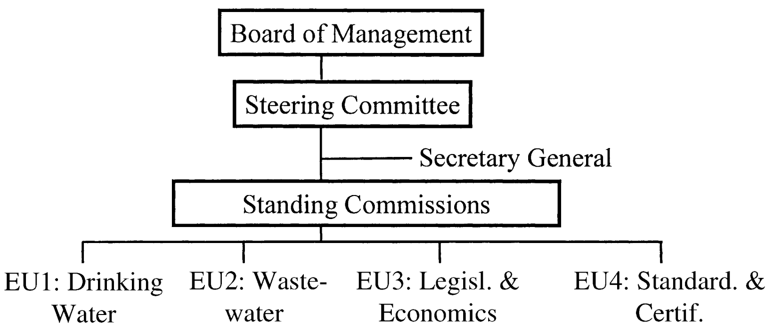

Fig. 1. Structure of Eureau.

2. Water resources management in Eureau countries

According to current United Nations demographic scenarios, the total population of the Eureau countries is expected to remain stable at around 380 million over the next 25 years and to decline slightly over the following 25 years to 350 million (see Table 1). This means that the six Eureau countries with a total freshwater availability of less than 3000 m^3/inh. yr today will still be six in 2025 but will only be four in 2050. However, this apparently reassuring situation hides problems that need to be addressed: (a) long-term pollution is affecting an increasing number of drinking water supplies (e.g. nitrates, pesticide residues); (b) the protection of sensitive areas will require the reduction of discharges; (c) irrigation is likely to increase its water consumption, in particular in the Mediterranean area (Anony., 1997a); and (d) global climate change appears to be pushing the European climate towards more extreme seasonal variations with more droughts in the dry seasons and more floods in the wet season, calling for a more robust water resources management.

In view of the current outlook for the use of water resources over the whole Eureau area, existing policies need to be re-oriented towards a better integrated water management while minimizing health and environmental risks. The forthcoming new European framework directive will lay the foundation for such an approach, including river basin-based management and water quality objectives. This should translate in a better control of polluting discharges over the long term.

In several countries hydrological plans have been drawn up (Spain and France) or are in the process of being drawn up (Greece and Portugal). These plans can be effective tools for action but the existing ones: (a) do not include integrated water resources schemes, (b) are dominated by the significance of short-term requirements, and (c) are still mostly turned more towards increasing water availability than towards better management of the water demands in spite of recent efforts to address these new challenges.

As a result, the re-use of reclaimed treated wastewater could become an important water management option both to shore up conventional resources and to reduce the environmental impact of discharges. Such re-use is foreseen within the water master plans of several countries and is already being done, but a number of technical and regulatory issues remain to be addressed to make sure it has no undesirable impact on the environment nor on public health. In addition, its safe practice still requires better control and appropriate training of the personnel practicing it.

3. Addressing water shortages

A number of Mediterranean Eureau members regularly experience severe water supply and demand imbalances, particularly in the summer months. This is due to the simultaneous occurrence of low precipitation, high evaporation and increased demands for irrigation and tourism. However, water shortages have also affected regions less used to such events, where periods of drought are becoming more frequent and long lasting, maybe as a result of global climate change. Numerous regions in France, Italy, Belgium, and the UK have suffered the negative impact of successive droughts over the last 10 years.

Table 1
Area, Population and annual renewable fresh water availability in European countries (Members of Eureau) for 1955, 1990, 1994, 2025, and 2050 years (UN, Population Division, 1994)

Country	Area (km^2)	Total renewable fresh waterer per year (km^3)	Fresh water availability in m^3/inhabitant									
			1955		1990		1994		2025[a]		2050[a]	
			Population (thousands)	Availability (m^3/inh. yr)	Population (thousands)	Availability (m^3/inh. yr)	Population (thousands)	Availability (m^3/inh. yr)	Population (thousands)	Availability (m^3/inh. yr)	Population (thousands)	Availability (m^3/inh. yr)
Austria	83,900	90.00	6947	12,955	7705.0	12,681	8039.9	11,194	8262	10,893	7811	11,522
Belgium	30,500	16.90	8868	1906	9951.0	1698	10130.6	1668	10,407	1624	10,068	1679
Cyprus	9250	0.90	530	1698	702.0	1282	728	1228	927	971	1006	895
Denmark	43,100	13.00	4439	2929	5140	2529	5215.7	2492	5081	2559	4819	2698
Finland	337,100	113.00	4235	26,682	4986.0	22,663	5098.8	22,162	5407	20,899	5373	21,031
France	544,000	185.00	43,428	4260	56,718.0	3262	58027.3	3188	61,247	3021	60,475	3059
Germany	356,900	200.00	70,326	2844	79,365.0	2520	81552.5	2452	76,442	2616	64,244	3113
Greece	132,000	69.00	7966	7406	10,238.0	5763	10442.4	5650	9868	5979	8591	6868
Ireland	70,300	50.00	2921	17,117	3503.0	14,273	3576.6	13,980	3882	12,880	4103	12,186
Iceland	103,000	170.00	158	1,075,949	255.0	666,667	—	—	337	504,451	365	465,753
Italy	301,300	187.00	48,633	3845	57,247.5	3267	57247.5	3267	52,324	3574	43,630	4286
Luxembourg	2600	5.00	305	16,393	381.0	13,123	406.6	12,297	439	11,390	420	11,905
Netherlands	41,200	90.00	10,751	8371	14,952.0	6019	15,422.8	5836	16,276	5530	15,275	5892
Norway	324,000	413.00	3427	120,514	4241.0	97,383	4245.0	97,291	4289	96293	4791	86,203
Portugal	92,400	66.00	8610	7666	9868.0	6688	9912.1	6659	9685	6815	9140	7221
Spain	504,800	111.00	29,199	3802	39,272.0	2826	39272.0[b]	2826	37,571	2954	31,765	3494
Sweden	450,000	180.00	7262	24,787	8559.0	21,030	8816.4	20,416	9751	18,460	9991	18,016
Switzerland	15,941	50.00	4980	10,040	6834.0	7316	6950	7194	7786	6422	7422	6737
UK	244,100	120.00	51,199	2344	57,411.0	2090	58,276.0[c]	2059	61,476	1952	61,635	1947
Total	686,390	2129.8	314,184		377,328.5		383,360.2		381,457		350,924	

[a] UN medium projection.
[b] 1990.
[c] 1993.

Several strategies have been developed in order to face water shortages. One is the construction of transfers from water rich watersheds to water-deficient areas. Such projects require very expensive investments and large civil engineering works, potentially creating a large environmental impact. Additionally, as most of the "easy" projects have already been built (e.g. canal de Provence in France, trasvase Tajo-Segura in Spain), such an approach becomes more and more difficult as the areas likely to benefit from the water transfer become ever more remote. One must also note that this practice also raise economic, institutional, cultural and political issues as shown by the discussions surrounding the recently failed water transfer project between the Rhône and Catalonia.

Other solutions can be implemented such as water savings (e.g. suppressing the leakage of supply networks, using more efficient irrigation techniques such as drip irrigation and small flush systems), tapping other resources (e.g. desalinating seawater or brackish water), and practicing wastewater re-use (Lazarova et al., 2000). Reducing demand through pricing is also a possible option but it raises many political difficulties, in particular, in countries where water is either free or paid through a flat fee.

Wastewater reuse can have two important benefits. The most obvious is the provision of an additional dependable water resource. The second is the reduction of environmental impacts by reducing or eliminating wastewater disposal, which results in the preservation of water quality downstream. Therefore, when considered in the framework of an integrated water management strategy at a catchment scale, the benefits of wastewater reuse should always been assessed taking into account that it contributes to both enhancing a region's water resource and minimising its wastewater outflow. In addition, using reclaimed wastewater for irrigation can reduce the need for fertilizer thanks to the nutrients it contains. This may even remove the need for tertiary wastewater treatment in sensitive areas.

The use of reclaimed wastewater for irrigation has been progressively adopted by virtually all Mediterranean countries (Marecos do Monte, Angelakis, & Asano, 1996). Israel was pioneer in this field, soon followed by Tunisia, Cyprus, and Jordan. More recently, European Mediterranean countries started considering wastewater reuse for irrigation. Although irrigation with wastewater is in itself an effective treatment (a sort of low-rate land treatment), some treatment must be performed previously for the protection of public health, the prevention of nuisances during storage and prevention of damage to the crops and soils (Asano & Levine, 1996). So far, in only a few countries worldwide is wastewater reclamation and reuse well enough established to have led to the drawing of specific regulations or guidelines. In a number of other countries (such as Cyprus) regulations concerning the use of reclaimed wastewater for irrigation are under preparation. Notice that, regulations refer to actual rules that have been enacted and are enforceable by governmental agencies. Guidelines, on the other hand, are not enforceable but can be used in the development of a reuse program.

4. Brief overview of wastewater reclamation and reuse in Eureau countries

Due to its generally abundant water resources, the EU has so far not invested heavily in wastewater reuse. However, this general situation hides very diverse realities. In Southern Europe wastewater reuse is still a limited, but growing, source of irrigation water. In Northern Europe, it is barely practiced but could be developed for sanitation or environmental protection purposes in response to increasingly stringent environmental regulations. It should be noticed that in Eureau countries, wastewater reuse has rarely been considered as an integral component of sanitation and overall water resources management (Anony., 1997b). In this section, we review the current practices and the potential of wastewater reclamation and reuse in various Eureau countries.

Austria: Austria has a mean yearly rainfall of ca. 1100 mm. The water consumption for drinking water corresponds to about 0.06% of rainfall, and for both agriculture and industrial purposes to about 1.5%. Due to this favourable situation, water scarcity in Austria is only a limited local problem mainly in some eastern and southern parts. Mean drinking water consumption is about 159 l/inh. d which is a moderate figure and has little changed during the last decade. About 98% of the drinking water derives from ground water and needs no or nearly no treatment. In Austria, the reuse of wastewater is only relevant where it contributes to reduce pollution and/or costs. Due to the water act, Austria has a very strong precautionary principle for ground and surface water protection. For a number of industries, the specific water consumption is limited by law to a value which can only be reached by recycling water (e.g. pulp and paper industry, sugar industry). As water is a renewable resource its reuse is only recommended if it results in overall economic and ecologic advantages. Therefore, the basic goal of water protection in Austria is to make rational use of water and to minimize material flows to the receiving waters. Source control of water pollution has a high priority.

Belgium: Today, only 38% of all sewage is currently treated in Belgium, with plans to treat 60% of the sewage shortly. This will improve the prospects for possible reuse. However, this will largely depends on the relative costs of traditional sources of water and reused treated wastewater. The amount of wastewater reuse is not known at the moment but remains limited. So far, the incentives to reuse wastewater have been lacking in Belgium. Nevertheless, in some situations, the reuse of treated wastewater could become increasingly attractive in areas of dropping water tables or high summer water demand such as the coastal regions during the tourist season. The elimination of discharges in environmentally sensitive areas is also a reason for developing wastewater reuse projects. The only documented case of established wastewater reuse in Belgium is that for the irrigation of crops, which is in operation in full scale. Mainly in summer time, the effluent of some wastewater treatment plants (WWTPs) is used for irrigation. Additionally, the University of Gembloux has developed a system, called "Epuvalisation", to reuse the effluent of WWTPs (and their nutrients) in hydroculture (Xanthoulis & Guillaume, 1995). Additionally, a pilot scale installation to produce drinking water out of the effluent of a WWTP is in use since June 1997.

Denmark: Denmark's five million inhabitants can count on a freshwater availability of approximately 2500 m^3/inh. yr. As in other Scandinavian countries, the issue of wastewater reuse has so far never been seriously considered. High water prices encourage industries to re-circulate process and cooling water.

Finland: With water availability per capita of more than 20,000 m^3/yr, Finland never needed to consider the reuse of treated wastewater for irrigation. The consumption of drinking water is 423 Mm^3/yr and over half of that is ground water. The industrial use of water is 1000 Mm^3/yr and the use of cooling water is 5700 Mm^3/yr. The need of irrigation in agriculture is quite low. The use of water for irrigation is less than 1% of the runoff and most of is high-quality surface water.

France: France has long irrigated crops with wastewater (close to a century), in particular, around Paris because, until 1940, it was the only method of treating and disposing of the wastewater of the Greater Paris conurbation. This practice is still going on in the Acheres region, where some of the wastewater is used after screening and settling but is likely to be discontinued soon. Interest in wastewater reuse rose again in the early 1990s for two main reasons: (a) the development of intensive irrigated farming (such as maize), in particular South-western France and the Paris region, and (b) the fall of water tables after several recent severe droughts which have paradoxically affected the regions traditionally considered to be the wettest (Western and North-western France).

Because of this new interest for wastewater reuse, the Health Authorities issued in 1991 the "Health guidelines for reuse, after treatment, of wastewater for crop and green spaces irrigation" (CSHPF, 1991). These guidelines essentially follow the WHO guidelines but add restrictions for irrigation techniques and set back distances between irrigation sites and residential areas and roadways. In February 1996, the Association of Water Supply and Sewerage Practitioners (AGHTM) published technical recommendations about the wastewater treatments necessary to ensure compliance with the French guidelines. Furthermore, recent French regulations make it compulsory for the departmental administration to apply for authorization for any wastewater reuse project (Bontoux & Courtois, 1996). A review of these guidelines is being considered.

Few projects have in fact been carried out up to now, mainly because of problems relating to the cost of tertiary treatments. The projects implemented cover more than 3000 ha of land, and quite a wide variety of applications: market gardening crops, orchard fruit, cereals, tree plantations and forests, grasslands, gardens and golf courses. The recent development of new treatment processes, such as membrane bioreactors (ultrafiltration, microfiltration), to obtain very high-quality purified water, disinfected and with no suspended solids, could change the approach to the problem and could open the door to recycling for domestic purposes (cleaning, toilet flushing, etc.). The reuse of industrial wastewater after purification to supply cooling water, wash water or even process water after sophisticated complementary treatment is widely developed in France.

Germany: In Germany, the usable amount of water reaches 182 billion m^3/yr. Only 25.8% of this is used: 15.8% by power stations 6% by industry, 3.1% by public water supply and 0.9% by agriculture. Therefore, there is little incentive for the recycling of wastewater. Germany has one of the lowest water losses in the EU. The main focus was on water pipelines, accounting for 63% of total investments. The mean domestic daily drinking water consumption is now 128 l/inh., the same level as 20 years ago. In some regions (e.g. Ruhr valley and Rhine valley) the artificial recharge of groundwater is practiced. In these cases, surface water or river bank filtrate is used as raw water for drinking water production. In some Lander, new regulations about the seeping of collected storm water have been ordinanced, but only when economic and ecological advantages could be achieved. Because the federal water act (Wasserhaushaltsgesetz) gives Germany a high level of protection for water, the best opportunity for the reuse of wastewater is through environmental protection schemes.

Greece: In Greece, water demand has increased tremendously over the past 50 years. Despite adequate precipitation, water imbalance is often experienced, due to temporal and regional variations of the precipitation, the increased water demand during the summer months and the difficulty of transporting water due to the mountainous terrain. In addition, in many south-eastern areas there is severe pressure for freshwater resources, which is exacerbated by especially high demand of water for tourism and irrigation. Therefore, the integration of treated wastewater into water resources management is a very important issue.

Today, almost 60% of the Greek population are connected to a WWTP with about 270 centralized WWTP, capable at treating 1.30 Mm^3/d (Tsagarakis, 1999). An analysis of data concerning the water balance of the areas of the treatment plants has been recently reported (Tchobanoglous & Angelakis, 1996). More than 83% of the treated effluents are produced in regions with a deficient water balance. Therefore, wastewater reuse in these areas would satisfy an existing water demand (Tchobanoglous & Angelakis, 1996). Several research and pilot projects dealing with wastewater reclamation and reuse are currently under way in Greece (Angelakis, Marecos do Monte, Bontoux, & Asano, 1999). In addition, a few small projects on wastewater reclamation and reuse are in practice, but no guidelines or criteria for wastewater reclamation and reuse have been yet adopted beyond those for discharge (No. E1b/221/65 Health Arrangement Action). A preliminary study is under way on the necessity for establishment of criteria in Greece (Angelakis, Tsagarakis, Kotselidou, & Vardakou, 2000).

Ireland: About 75% of Irish drinking water is abstracted from surface water, the remainder supplied by wells and boreholes. Some 1000 public water supply schemes deliver in excess of 1.2 Mm^3 of water per day. Because of the mild and wet Irish climate, the need of irrigation in agriculture is practically non existent. Cooling water tends to be pumped directly from rivers or lakes. We are not aware of any voluntary reuse of wastewater in Ireland.

Italy: A first survey of Italian treatment plants estimated the total treated effluent flow at 2400 Mm^3/yr of usable water. This gives an estimate of the potential resource available for reuse. In view of the regulatory obligation to achieve a high level of treatment, the medium to large-sized plants (> 100,000 inh. served), accounting for approximately 60% of urban wastewater flow can provide re-usable effluents for a favorable cost/benefit ratio. The use of untreated wastewater has been practiced in Italy at least since the beginning of this century, especially on the outskirts of small towns. Among the oldest cases of irrigation with wastewater is the "marcite" where water from the Vettabia river, which receives most of the industrial and urban untreated wastewater, is used.

Existing Italian legislation (General Technical Standards — G.U. 21.2.77) sets the limits in relation to the type of vegetables and grazing crops to 2 and 20 colibacteria per 100 cm^3, respectively. Moreover, the law prescribes that in the presence of surface aquifers in direct contact with surface waters adequate preventive measures must be used to avoid any deterioration of their quality. A new law relative to municipal wastewater is being prepared that gives better attention to the management of water resources and in particular to the reuse of treated wastewater. Industry will be encouraged to use treated wastewater. Municipal wastewater treatment companies have already planned to build a separate supply network for wastewater reuse by industries. In the metropolitan area of Turin, for example, the two main companies (Azienda Po Sangone (APS) and CIDIU) have already done so. Finally, a proposal for establishing national regulations on wastewater reclamation and reuse is in preparation.

Norway: Approximately 87% of the population receives water from local watersheds and 13% from groundwater. Approximately 90% of the population is supplied with water from 1600 waterworks. The rest is supplied from small private works. 400 of the public water works produce water with quality according to EU requirements, supplying 60% of the population (including

Oslo). 1200 smaller waterworks produce water not up to these standards, supplying 30% of the population. According to national statistics Norwegian waterworks deliver nearly 600 l/cpd but only 130 l/cpd are used in private households. Industrial consumption equals 100 l/cpd and an additional 100 l/cpd is used in business undertakings, institutions and municipal technical works. These figures indicate a total leakage of 40–50%. The Norwegian Government has recently decided to allocate approximately NOK 100 million each year for 5 years for upgrading and improving local water supplies. As Norway is blessed with an abundance of fresh water, the issue of wastewater reuse is rarely considered. But because of high water tariffs in certain areas some industrial companies are recirculating processing and cooling water.

Luxembourg: The average yearly rainfall is 785 mm (two billion m^3). National consumption of drinking water is around 60 Mm^3 yearly corresponding in average to 300 l/cpd. Industry needs 25%, agriculture 30% and households 45%. Today, surface water (maximum 60,000 m^3/d) covers about 1/3 of the average water consumption and up to 2/3 of the summer peaks. For more security of the surface water, complementary new groundwater wells (maximum 50,000 m^3/d) were dug some years ago. As Luxembourg has no real problem in providing fresh drinking water, wastewater reuse does not rank high on the agenda of the country. Nevertheless, in order to protect its watercourses especially in summer, when the levels are low, some provisions have been made: industry generally is encouraged to recirculate process and cooling water. In the same idea, storage of rainwater is encouraged for irrigation and cleaning purposes in industry, agriculture and households. The use of treated wastewater is being considered for humidification in the compost industry.

Portugal: In Portugal, treated wastewater is a valuable potential resource for irrigation. On the other hand, the volume of treated wastewater available in Portugal should soon reach 580 Mm^3, approximately twice as much as today. This, even without storage, could be enough to cover about 10% of the water needs for irrigation in a dry year. The use of treated wastewater for irrigation could significantly contribute to the agricultural development in the driest Portuguese provinces (Beja, Evora, Setubal, Lisboa and Santarem). Roughly, between 35,000 and 100,000 ha, depending on storage capacity could be irrigated due to treated wastewater. Interest is also growing for the irrigation of golf courses. There are a few cases of planned irrigation with treated waste water, specially orchards and vineyard and golf courses, in the southern half of the country. Very little monitoring data is available. A large WWTP (460,000 p.e. in the year 2000) presently, in construction, near Lisbon, plans to irrigate 1000 ha with tertiary treated wastewater. Finally, the production of Portuguese guidelines for waste water reuse for irrigation is being considered (Marecos do Monte et al., 1996).

Spain: A new National Hydrological Plan has been recently published which is favorable to the reuse of treated wastewater for irrigation. In any case, the reuse of treated wastewater is already a reality in several Spanish regions for different applications: golf course irrigation, agricultural irrigation, groundwater recharge (in particular, to stop saltwater intrusion in coastal aquifers) and river flow augmentation. Commercial interest exists and some private water companies invest in Research and Development activities, in collaboration with the Universities (e.g. AGBAR and Canal de Isabel II).

Sweden: In areas where water is scarce, especially for irrigation, wastewater is an obvious resource. Such has been the case in Sweden, where wastewater has been collected in large reservoirs for up to nine months before irrigation. The benefits with these projects have been mainly twofold: (a) waste water treatment in a safe and financially attractive way and (b) creating water resources for agricultural irrigation. These schemes have meant, that wastewater treatment is handled in a cheap but very efficient way. Nutrients in the wastewater are recycled to farm land and the farmers are provided with cheap irrigation water. It is profitable for the Water Utility since it is selling water instead of constructing and operating expensive sewage treatment plants and for the farmers, since they secure and increase their harvests and they can also buy water cheaper than they had been able to do if they had constructed their own irrigation systems. This is also an ecological solution that avoids all discharges of more or less treated sewage water. This could also provide a more direct path to sustainable wastewater treatment than is normally the case in the western world.

Switzerland: Today, 95% of the population are connected to sewage treatment plants. All plants are equipped with mechanical and biological treatment; 75% of the waste water is purified with supplemental chemical treatment. Water quality in surface waters is good or very good, but in regions with intensive agriculture, nitrate concentrations in groundwater are often higher than 25 mg/l and in some cases even higher than even 40 mg/l. Groundwater from other sources ($>70\%$) is used directly or can be processed with one purification step to produce drinking water of good quality. For larger agglomerations lakes act as reservoirs for the production of drinking water. The amount of water used for irrigation is not well known; abundance of water resources does not favour tight control. Because of well-developed hydraulic infrastructure and enough rain Switzerland has not a high demand for wastewater reuse. High-quality standards for surface waters and stringent concentration levels for hazardous substances in wastewater discharges favour water reuse in industrial processes in order to minimize high treatment costs.

The Netherlands: Some regions in the Netherlands (in the south-west, east and north-east of the country) can experience water shortages during dry spells. Reuse of effluent for irrigation is only possible when the quality of the effluent is sufficient: for crop irrigation, chlorine and iron are the limiting substances at present. The bacteriological quality of the effluent is mostly too poor to meet the standards for drinking water for cattle and for bathing waters. Reuse of effluent can be a good option for certain industrial applications such as cooling systems, water for cleaning and so on. So far, the total amount of reused treated wastewater in the Netherlands is small. At local level effluent is used for maintenance of the water level, water for fire-fighting and so on. Reuse of water very much depends on the local situation: availability of a "good-quality" effluent at a "competitive" distance (compared to surface water). In the near future, reuse will probably increase. In agriculture effluent will be stored and even treated to meet the standards required for this purpose. Water boards are also considering an additional treatment (sand filtration) after tertiary treatment if the effluent can be used for (ground) water supply in forest areas or other nature areas. For industries, the reuse of wastewater will be an option if it is cost-efficient. With the Dutch government imposing taxes and limits on aquifer abstraction to reinstate original groundwater level, industrial wastewater reuse is becoming increasingly interesting.

UK: The UK has used sewage effluents to maintain river flows (and ecosystems) and through river abstractions to contribute towards potable water and other supplies. This practice is particularly developed for the major rivers in the South and East where it is not always feasible to abstract upstream of sewage works. There are some examples of direct treated wastewater reuse, mainly for irrigation purposes — golf courses, parks, road verges, etc. — but also for commerce — car washes, cooling, fish farming, etc. Several schemes are being piloted to recycle wastewaters from washing machines, baths and showers, etc., for the flushing of toilets that accounts for a third of domestic wastewater reuse. In some of these, rainwaters collected from the roof of the house in question are combined with the wastewater. Overall, there is no consistent or extensive pattern of treated wastewater reuse in the UK. Normally, there has been sufficient water to meet demand so relatively few schemes for reuse have been developed. After the droughts of the last few years, these are expected to increase significantly with considerable public, political and climatic pressure in the UK to use water wisely, subject to appropriate assurances about quality and costs.

5. Legislation and guidelines for wastewater reuse at European level

So far, no regulation of wastewater reuse exists at European level. The only reference to it is the article 12 of the European Wastewater Directive (91/271/EEC) (EU, 1991) stating: "*Treated wastewater shall be reused whenever appropriate*". In order to make this statement reality, common definitions of what is "appropriate" are needed. The forthcoming EU Framework Directive does not specifically mention the desirability of wastewater reuse, but it introduces a quantitative dimension to water management, on top of the usual qualitative dimension, which may stimulate the consideration of wastewater reuse. It also states that "*water resources should be of sufficient quality and quantity to meet other economic requirements*". Wastewater reuse being a water resource often mobilized for economic reasons, such a statement does have economic implications (Angelakis et al., 1999).

As we have just seen, there are many different attitudes towards wastewater reuse across Europe. There is now an effort to harmonize the various approaches to wastewater reuse at European level. A group of international experts has been convened at the initiative of WHO and of the European Commission to review the state-of-the-art and produce guidance for European guidelines.

6. A variety of approaches in regulating wastewater reuse

So far, a variety of approaches has been taken by different agencies to regulate water quality for wastewater reuse systems across Eureau countries. These differences pertain mostly to the existing irrigation practices, local soil conditions, the desire to protect public health, the choices of irrigation and wastewater treatment technologies and the need to keep costs down.

Existing wastewater reuse guidelines typically cover four areas for each application: physicochemical standards, microbiological standards, wastewater treatment processes and irrigation techniques. The degree of treatment required and the extent of monitoring necessary depend on the specific use (e.g. landscape irrigation or crop irrigation) and crop (e.g. eaten cooked or raw). In general, irrigation systems are categorized according to the potential degree of human exposure (e.g. long-range exposure through spray irrigation and short exposure through drip irrigation). The highest degree of treatment is always required for irrigation of crops that are consumed uncooked (the so-called "unrestricted" irrigation). Health risks associated with both pathogenic microorganisms and physico-chemical constituents, including persistent organic pollutants, need to be addressed where reclaimed water is used for indirect potable water supply augmentation.

A brief comparison of criteria (maximum limits) for reclaimed wastewater reuse is given by Angelakis et al., 1999. Outside of Europe, most countries, such as Israel (a notable Mediterranean exception) and South Africa and recently Japan and Australia, shy away from accepting the 1989 WHO guidelines (WHO, 1989), considered too lenient for public health protection in industrialized countries. Around the Mediterranean however, and particularly in Europe, while the competent authorities recognize the limitations of the WHO guidelines, most existing regulations and guidelines follow them but contain additional criteria such as treatment requirements or use limitations in order to ensure proper public health protection. This is in particular the case of the French guidelines. Traditional practices and economic considerations appear to be weighing heavily on the debate. While there appears to be a wide agreement that the 1989 WHO guidelines are only a minimum requirement (i.e. insufficient), there is so far no general consensus on the best approach to follow. The California approach has developed the most data in its own support and seems to become established in some parts of the world. Its basic advantage is its "safety first" philosophy but it is the most expensive and disregards established traditional practices and local socio-economic conditions in many areas of the world. As a result, there remain a number of experts in favor of a "Third Way", somewhere between the California and the WHO approaches. Developing a consensus on such a "Third Way" would make a lot of sense, in particular for the areas where international tourism and the export of agricultural products are significant and the areas where wastewater reuse is mainly performed for environmental protection (Angelakis et al., 1999). Nowadays, both California regulations and WHO guidelines are under revision. In addition, various studies are under way which are directed in developing minimal physicochemical and microbiological criteria for wastewater reclamation and reuse in Greece, in Italy, in Spain and other countries. These criteria are closest related to California regulations, however, the 1989 WHO philosophy is in some way included.

7. Conclusions

Most of the northern Eureau countries have abundant water resources and they all give priority to the protection of water quality. In these countries, the need for extra supply through the reuse of treated wastewater is not considered as a major issue, but the protection of the receiving environment is considered important. However, industry is generally encouraged to recycle water and to reuse reclaimed wastewater. The situation is different in the southern Eureau countries, where the additional resources brought by wastewater reuse can bring significant advantages to agriculture (e.g. crop irrigation) and tourism (e.g. golf course irrigation). Therefore, considering its various potential benefits, wastewater reclamation and reuse can be applied to the advantage of both northern and southern Eureau countries (protection of water resources, prevention of coastal pollution, recovery of nutrients for agriculture, augmentation of river flow, savings in wastewater treatment, groundwater recharge, and sustainability of water resource management, etc. Therefore, Eureau could be involved in the future in setting up international best practices and guidelines related to the reuse of treated wastewater. Such criteria and/or guidelines should contribute to a better management of water resources, a better protection of public health and of the environment and to a more sustainable development.

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