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# Standards of Wastewater Reuse/Disposal in KSA: Reconsideration

**Omar S. Aburizaiza[a], Gohar A. Mahar[b*]**

[a]Unit for Ain Zubaida Rehabilitation and Groundwater Research, King Abdulaziz University, Jeddah, Saudi Arabia

[b]Department of Geography, Federal Urdu University of Arts, Science and Technology, Karachi, Pakistan

*Email: goharmahar@gmail.com

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**Abstract:** Ministry of Agriculture and Water (*MAW*) in Saudi Arabia had setup very stringent standards for wastewater reuse and discharge (*WWRD*) in 1989, for example, turbidity and nitrate as nitrogen were not to exceed 1NTU and 10 mg/l respectively. Those limits cannot be met without additional expensive tertiary treatment. Those standards are not needed for all WWRD. In fact, secondary treatment with disinfection and efficient management are adequate for most of WWRD. The author published an article back in 1999 in Water Research Journal, Vol. 33, in which he assessed the standards and recommended setting up less stringent standards as a function of intended reuse and method of irrigation. The standards were re-evaluated and modified by MAW and other ministries in 2003, 2005 and 2006. Unfortunately, the modifications were not to the expected level, and still only a small part of treated wastewater is being used. The remaining portion of wastewater is discharged into a wadi/sea. This article reassessed the standards published in 2003, 2005 and recommended setting up revised standards for reuses and discharges relevant to the intended uses and discharges.

**Keywords:** Wastewater, reuses, discharges, standards Saudi Arabia.

## Introduction

Wastewater reuse is very promising approach for improving water resource management in all over the world (Gomez-Lopez et al., 2009). This approach seems to be more significant in arid and semi-arid countries those are facing quantitative and qualitative water challenges (Mirabi et al., 2014). Mathematical and spatial formulation is required to minimize the number of treatment plant and their cost. Many proposals have been formulated to modify the structure and reduce the budget and cost (Elbert E. 1976, Russel and Singleton 1986, Malcolm and Bruce 2010, Margarita 2012), because technically operating and design characteristics of the plant can economically minimize cost (Gregory and Virgina 2010).

More than 50% of world desalinated water is utilized by Middle East countries (Yasser et al. 2000; Alhumoud et al. 2003). In many of the Middle East countries, wastewater is becoming preferred unconventional source of water (Abu Maadi 2004). In Middle East, quantity of reused treated wastewater is increasing for the last four decades and about 50 to 70% of the total volume of wastewater is treated to meet their requirement for increasing population (EPA 2004). Agriculture use of water is very dominant over domestic or industrial use in GCC countries (Alhumoud et al. 2003). Water reuse index (WRI) of Jordan has been increase from 30% to 38% between period 2004 and 2007 (Alfarra et al. 2011), Similarly, Tunis is also reusing treated wastewater for the purpose of groundwater recharge and irrigation since 1965 (El Ayni 2011). With recent advances in Technology and design treating municipal wastewater and reusing it for irrigation, industry and other applications could significantly increase the city like Madinah's total available water resources (Saud Al Gutub, 2013).

Kingdom of Saudi Arabia (KSA) is an arid country (Hussain and Al Saati, 1999) with low and erratic rainfall (El Mahamoudi et al. 2011) where scarcity of water is prominent issue. Available freshwater could not meet the demand of increasing population, urbanization and development of industrial sector in KSA (Aburizaiza, 1999). For the last four decades, the government has always endeavored to provide the quality of water to the people living in KSA by strategic plan of treatment seawater and wastewater for use in many sectors. The relevant ministries and agencies, e.g., Ministry of Agriculture (MA), Ministry of Water and Electricity (MOWE), Ministry of Municipalities and Rural Affairs (MMRA), Presidency of Meteorology and Environment (PME), and National Water Company (NWC) set up several standards and modified the old ones (of wastewater reuse). However, the modified and revised standards are still not up to the level to enable feasible water reuse activities within the kingdom.

The main objective of this article is to thoroughly discuss the standards of wastewater reuse/disposal in KSA, indicate their negative points and elaborate the new standards and recommend further modifications, and improvements. A systematic overview of municipal water use and distribution network and sewerage system was studied. Wastewater reuse and discharge standards and their medication are discussed and analyzed. The comparative standards of wastewater reuses and discharges of several states in the USA (United States of America) which are environmentally similar to KSA are studied to identify the merits and demerits and to give recommendations.

## Historical Review of Reused Wastewater Standards in KSA

Back in November, 1999, an article titled "Modification of the Standards of Wastewater Reuse in Saudi Arabia" was published in Water Resources Research Journal (Vol. 33. No. 11, pp. 2601-2608). The main theme of the article was to evaluate the standards, critically analyze and suggest modifications and development of standards for different reuses and discharges of treated wastewater (Aburizaiza, 1999). The published article pointed out that the Saudi standards for wastewater reuses and discharges were very stringent and imposed unnecessary limitations on disposal and reuse. Moreover, in another article in 2016, a critical appraisal of the use of tertiary treatment was done by elaborating negative impact. This article also showed some limitation and recommended many modification against that was that was issued in 2000 (Aburizaiza and Mahar 2016). In fact, these standards significantly reduced agricultural uses, and imposed near drinking water quality on reuse of wastewater. The article argued the case for a discriminating set of standards. It further claimed that this would allow a variety of reuses and recommended setting up standards less stringent for different wastewater reuses, and discharges, when and where it is environmentally acceptable, and economically feasible.

MAW has been restructured and now functioning with the new name of the Ministry of Agriculture (MA). Currently, the Ministry of MOWE is responsible for municipal water in KSA. The MA has modified several parameters of the water reuse standards. Still, more work is required to build up effective standards and specifications for water reuses and discharges. *MMRA* in 2003 and 2005 and MOWE in 2006 modified the standards slightly as shown in Table (4).

The Saudi standards and specifications for wastewater discharge into the sea which were prepared and set up by Presidency of Meteorology and Environment (PME) in 1989 have not been changed since then. The same statement was provided to the author of this article by the officials at PME. In fact, author checked but could not find any new standards either in the PME publications or in the literature. Thus, the analysis and recommendations of the previous article (1999) still apply.

## Municipal Water uses and Network in KSA

Municipal water uses in 2013 was around 2,731 million $m^3$ in KSA. The major source of water supply was desalinated water, groundwater and surface water (Table 1). The author could not separate the collected information of groundwater and surface water from reservoirs behind the dams.

Although the major source of water supply for the cities is desalinated water; and for towns and villages is groundwater, the general trend is to shift from groundwater to desalted water. This should be considered as a major factor in setting up the standards of the disposal and reuses of wastewater. Desalted water is free from heavy metals and trace elements. In fact, TDS is usually less than 50 mg/l. Groundwater is added to rise up the TDS to about 100mg/l to make the water palatable.

The public water network systems among cities and towns ranges from 35% to 90%. The remaining is served by bowsers. The source of supply by bowsers in big cities is partly the desalinated water. However, in

Table 1 Water uses in Saudi Arabia[a].

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Desalination (million $m^3$) | 1,067 | 1,063 | 1,145 | 1,258 | 1,476 | 1,546 | 1,594 |
| % of total water use | 54 | 53 | 54 | 55 | 61 | 61 | 58 |
| GW & Dams reservoirs (million $^3$) | 910 | 942 | 978 | 1,025 | 947 | 981 | 1,137 |
| % of total water use | 46 | 47 | 46 | 45 | 39 | 39 | 42 |

[a]Annual Report, (2011, 2013) Ministry of Water and Electricity (MOWE), Riyadh, Saudi Arabia.

Table 2 Connections and length of water network in the Urban Areas in KSA regions in 2014[b]

| Region | Riyadh | Mecca | Madina | Qaseem | Eastern region | Aseer | Tabouk | Hail | Norther region | Jazan | Najran | Baha | Jouf | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Connections in (000)** | 630 | 545 | 137 | 119 | 422 | 58 | 54 | 63 | 26 | 112 | 51 | 23 | 51 | 2291 |
| **pipes Lengths in (000 km)** | 21.4 | 19.2 | 5.4 | 6.7 | 11.3 | 3.2 | 2.6 | 1.9 | 1 | 3.8 | 1.8 | 1.1 | 1.4 | 80.8 |

[b]Ninth Development Plan, (2009-2014), Ministry of Planning, Saudi Arabia

the towns, the main source is groundwater from the wells. The quality of groundwater may not meet the quality of drinking water standards. Usually, it is chlorinated before it is distributed for users. It should be noted that people of rural areas in Saudi Arabia are used to drinking-water with a TDS of about 500 mg/l for centuries with no apparent complaint or effect (Aburizaiza, 1994).

In the urban areas, work is in progress to complete the public water network and sewerage system. In the 9th Development Plan (2009-2014) the annual growth rates for water connections, water pipe lengths and sewerage connections was 12.3%, 14.5% and 6.4% respectively Table 2.

Table 2 shows that considerable efforts are needed to cover all urban areas with the public water network. The availability of the public water network will enable the relevant ministries to control the municipal drinking water supplies and to make sure it does meet the drinking water standard.

**Sewerage System and Treated Wastewater Reuses**

The estimated quantity of the wastewater of the municipal areas is around 2.6 million cubic meters per day ($MCMD^{-1}$) (*MOE* Annual Report, 2013). Unfortunately, the public sewerage system covers only a small percentage of the cities. Currently, several towns practically do not enjoy the services of the sewerage systems. The remaining wastewater flows into cesspits. This is the main reason that the number of the connections (residential and commercial units) are small (1,115,997), and consequently the collected quantities of wastewater are also small (Table 3).

Number of wastewater treatment plants has not been changed since 2010, though some are under construction. Due to the absence of a complete sewerage system, adverse issues in health, social, economic and environmental dimensions have been developed. The total amount of reused treated wastewater was small 0.4975 million $m^3$/day in 2013 (Table 3).This situation demands more wastewater reuse activities. In fact, in an arid country such as Saudi Arabia, every drop of water should be used efficiently.

As mentioned earlier, due to the absence of a complete sewerage system, municipal wastewater is discharged into cesspits. When the groundwater table rises, wastewater has to be pumped out from cesspits by bowsers and discharged into wastewater treatment plants, if available. If treatment plants are not available, then wastewater is to be discharged untreated into the sea/wadi (Arabic term traditionally referring to a valley). Some of the light industrial and commercial units like car washing and car workshops, schools and hospitals may have some heavy metals and trace elements, though they are of a small amount. If it is considerable, it may affect the biological system of treatment plants. Also, some of the residential wastewater in holy places (Arafat, Muzdalifa and Mina), where water is used mainly for toilet flushing, is very strong where $BOD_5$ values up to 500 mg/l have been reported (Aburizaiza, 1999). Therefore, there is a need for pretreatment to control the quality of wastewater which is disposed into the sewer system/wastewater treatment plants, to make sure that its quality is similar to the designed quality of the urban wastewater so sewerage and wastewater treatment plants will not be affected by strong wastewater.

The design capacity of almost all wastewater treatment plants in Saudi Arabia is about 4.7 million $m^3$/day (Table 3). This is larger than what is needed today. It seems that the design capacity is intended to take the expected future wastewater generation into consideration. Furthermore, the amount of raw wastewater seems to be higher than the sewer flow. This is due to the fact that some wastewater pumped out of cesspits is being treated in the wastewater treatment plants, if the plants are available. If not available, wastewater is discharged into the seas or Wadis

Table 3 further shows that only 14% of the treated wastewater is being used, consequently, the remaining 86% is being discharged into seas and Wadis. Therefore, here, discharge is a major issue and separate standards for types of discharge locations should be set up.

The data collected from different departments in KSA in different time periods, show maximum allowable level of contamination in restricted and unrestricted irrigation (Table 4a). Restricted irrigation is limited to watering of trees, fodder, fiber and seed crops. In this irrigation system, treated wastewater is not allowed for cultivated crops. Unrestricted irrigation allows watering of cash crops and food crops that are used for human consumption and eaten uncooked, respectively.

Table (4a) shows the old and the new standards for unrestricted and restricted irrigation water reuse in KSA. This table also shows that monthly average $BOD_5$ and TSS for unrestricted irrigation remain unchanged at 10mg/l. The weekly average also remains the same as 15mg/l or undefined. For restricted irrigation, monthly average of $BOD_5$ rose from 20 to 40mg/l or undefined.

Al, As, Be, Cd, Co, Cn, Fe, Pb, Li, Mn, Hg, Mo, Nitrate-nitrogen, Se and Phenol remained unchanged in MOWE 2006 standard, and these standards do not discriminate between restricted and unrestricted irrigation (Al-Jasser, 2011). Other elements: B, Cr, Ni, V and Zn were raised from 0.5, 0.01, 0.02, 0.01 and 2 mg/l, to 0.75, 0.1, 0.2, 0.1 and 4 mg/l, respectively. In MMRA 2003 and 2005, standards were not identified in restricted irrigation. Chromium rose from 0.01 to 0.1 mg/l, Fluoride (F), however reduced it from 2 to 1.

Fecal coliforms remain the same at 2.2/100 ml (MPN) for unrestricted irrigation, while it was raised from 100 to 1000/100 ml (MPN) for restricted. Intestinal nematodes/l remains the same as one while turbidity rose from 1 to 5 NTU.

Readers can easily notice that not much efforts have been done to make wastewater reuse and discharge less stringent. Table (4,a) also shows that values of the standards are mostly the same for restricted and unrestricted irrigation. The standards were set up as if there is one kind of crop and one method of irrigation though each crop has its own characteristics and each irrigation method has its own criteria. Most of the other contaminants listed in Table 4.a are either not removed at all, or partly reduced in concentration by conventional treatment. Most of the existing wastewater treatments in KSA are of conventional type.

The standard is particularly stringent with respect to nitrogen in irrigation. The reduction in nitrate nitrogen to 10mg/l requires biological nitrification and de-nitrification, plus chemical de-nitrification. Yet, if the

Table 3 Sewerage systems and operational data of sanitation in Saudi regions in 2013[c].

| Region | Sewer system | | Wastewater treatment plants | | Operational data of sanitation | | |
|---|---|---|---|---|---|---|---|
| | *No. of Connections in 2014 (Region %)* | *Piped length (km) (Region % of sewer )* | *No. of plants (Region %of total saudi plants )* | *The design capacity $m^3/d$ ( region wise %)* | *treated wastewater $m^3/d$* | *used treated wastewater $m^3/d$* | *% of used treated wastewater* |
| Riyadh | 350918 (31.4) | 5,662 (19.6) | 13 (16) | 947,265 (20) | 961,173 | 135,549 | 14 |
| Mecca | 218300 (19.6) | 6,002 (20.8) | 14 (17.3) | 978,000 (20.6) | 841,479 | 57,515 | 7 |
| Madinah | 53535 (4.8) | 2,406 (8.3) | 1 (1.2) | 300,000 (63.3) | 162,739 | 2,958 | 2 |
| Qaseem | 115936 (10.4) | 2,539 (8.8) | 5 (6.2) | 144,000 (3) | 144,000 | 45,000 | 31 |
| Eastern Region | 225462 (20.2) | 5,416 (18.7) | 21 (25.9) | 1,785,350 (37.7) | 947,280 | 234,626 | 25 |
| Aseer | 74695 (6.7) | 3,140 (10.9) | 18 (22. 2) | 366,632 (7.7) | 188,700 | 11,400 | 6 |
| Tabouk | 28243 (2.5) | 758 (2.6) | 1 (1.2) | 60,000 (1.3) | 120,000 | 3,000 | 3 |
| Hail | 9000 (0.8) | 880 (3.1) | 1 (1.2) | 12,000 (0.3) | 17,000 | 150 | 1 |
| Northern Borders | 8407 (0.8) | 220 (0.8) | 2 (2.5) | 24,000 (0.5) | 11,500 | 0 | 0 |
| Jazan | 13429 (1.2) | 489 (1.7) | 2 (2.5) | 20,000 (0.4) | 18,450 | 4,780 | 26 |
| Najran | 3530 (0.3) | 890 (3.1) | 1 (1.2) | 60,000 (1.2) | 3,250 | 250 | 8 |
| AlBaha | 0 (0) | 50 (0.2) | Data unavailable | Data unavailable | 500 | 500 | 100 |
| Al Jouf | 14542 (1.3) | 445 (1.5) | 2 (2.5) | 40,000 (0.8) | 38,000 | 0 | 0 |
| Total | 1115997 (100%) | 28,897 (100%) | 81 (100%) | 4,737,247 (100%) | 3,454,071 | 495,728 | 14 |

Annual report, (2011 & 2013, MOWE), Ministry of Water and Electricity, Riyadh, Saudi Arabia.

water is intended for watering crops, and the crops are not sensitive to high nitrogen compound, the nitrogen, beneficial as an essential nutrient in plant growth, should not be removed as long as local groundwater quality is not affected.

In addition, heavy metal contamination of soils is more likely to occur from application of wastewater sludge than from the irrigation of domestic wastewater, and certainly the allowable limits need not be as low as almost drinking water standards to protect crops and soils.

Table 4a Maximum contaminant levels in restricted and unrestricted irrigation water in Saudi Arabia.

| Parameter in mg/l | | MAW 1989 | | MMRA 2003 | | MMRA 2005 | | MOWE 2006 | |
|---|---|---|---|---|---|---|---|---|---|
| | | *Unrestricted irrigation* | *Restricted irrigation* | *Unrestricted irrigation* | *Restricted irrigation* | *Unrestricted irrigation* | *Restricted irrigation* | *Unrestricted irrigation* | *Restricted irrigation* |
| $BOD_5$ | Monthly average | 10 | 20 | 10 | 40 | 10 | 40 | 10 | 40 |
| | Weekly average | 15 | 30 | NA | NA | | | 15 | NA |
| Monthly average TSS | | 10 | 20 | 10 | 40 | 10 | 40 | 10[d] | 40 |
| Aluminum (Al) | | 5 | 5 | 5 | NA | 5 | NA | 5 | 5 |
| Arsenic (As) | | 0.1 | 0.1 | 0.1 | NA | 0.1 | NA | 0.1 | 0.1 |
| Beryllium (Be) | | 0.1 | 0.1 | 0.1 | NA | 0.1 | NA | 0.1 | 0.1 |
| Boron (B) | | 0.5 | 0.5 | 0.75 | NA | 0.75 | NA | 0.75 | 0.75 |
| Cadmium (Cd) | | 0.01 | 0.01 | 0.01 | NA | 0.01 | NA | 0.01 | 0.01 |
| Chromium (Cr) | | 0.01 | 0.01 | 0.01 | NA | 0.01 | NA | 0.1 | 0.1 |
| Cobalt (Co) | | 0.05 | 0.05 | 0.05 | NA | 0.05 | NA | 0.05 | 0.05 |
| Copper (Cu) | | 0.4 | 0.4 | 0.2 | NA | 0.2 | NA | 0.4 | 0.4 |
| Cyanide (Cn) | | 0.05 | 0.05 | 0.05 | NA | 0.05 | NA | NA | NA |
| Fluoride | | 2 | 2 | NA | NA | NA | NA | 1 | 1 |
| Iron (Fe) | | 5 | 5 | 5 | NA | 5 | NA | 5 | 5 |
| Lead (Pb) | | 0.1 | 0.1 | 5 | NA | 5 | NA | 0.1 | 0.1 |
| Lithium (Li) for citrus fruits | | 2.5 | 2.5 | 2.5 | NA | 2.5 | NA | 2.5 | 2.5 |
| **Parameter in mg/l** | | **MAW 1989** | | **MMRA 2003** | | **MMRA 2005** | | **MOWE 2006** | |
| | | *Unrestricted irrigation* | *Restricted irrigation* | *Unrestricted irrigation* | *Restricted irrigation* | *Unrestricted irrigation* | *Restricted irrigation* | *Unrestricted irrigation* | *Restricted irrigation* |
| Manganese (Mn) | | 0.2 | 0.2 | 0.2 | NA | 0.2 | NA | 0.2 | 0.2 |
| Mercury (Hg) | | 0.001 | 0.001 | 0.001 | NA | 0.001 | NA | 0.001 | 0.001 |
| Molybdenum (Mo) | | 0.01 | 0.01 | 0.01 | NA | 0.01 | NA | 0.01 | 0.01 |
| Nitrate as N | | 10 | 10 | 10 | NA | 10 | NA | 10 | 10 |
| Nickel (Ni) | | 0.02 | 0.02 | 0.02 | NA | 0.02 | NA | 0.2 | 0.2 |
| Selenium (Se) | | 0.02 | 0.02 | 0.02 | NA | 0.02 | NA | 0.02 | 0.02 |
| Vanadium (V) | | 0.01 | 0.01 | 0. 1 | NA | 0. 1 | NA | 0. 1 | 0.1 |
| Zinc (Zn) | | 4 | 4 | 2 | NA | 2 | NA | 4 | 4 |
| Phenol | | 0.002 | 0.002 | 0.002 | NA | 0.002 | NA | 0.002 | 0.002 |
| Oil and grease | | Absent | Absent | Absent | NA | Absent | NA | Absent | Absent |
| pH | | 6.0-8.1 | 6.0-8.4 | 6.0-8.4 | NA | 6.0-8.4 | NA | 6.0-8.4 | 6.0-8.4 |
| Fecal coliforms per 100 ml | Avg. of last seven samples | 2.2/100ml | 100/100ml | 2.2/100 ml (MPN method or equivalent) | 1000 colonies/100 ml | 2.2/100 ml (MPN method or equivalent) | 1000 colonies/100 ml | 2.2/100 ml | NA |
| | Max. of any one sample | 23/100ml | 200/100ml | | | | | 23/100ml | |
| Intestinal nematodes per liter | | 1 | 1 | 1 | 1 | 1 | NA | 1 | 1 |
| Turbidity | | 1 | 1 | NA | NA | NA | NA | 5 | 5 |

[d]The table shows the maximum level of contamination of trace elements used for restricted and unrestricted irrigation in Saudi Arab.

**Source:** The data collected from *MAW* 1989 wastewater standards, *MMRA* 2003 wastewater standards, *MMRA* 2005 wastewater standards, and *MOWE* 2006 wastewater standa

The prescribed levels of chemicals listed in Table 4a as contaminants are applied universally for all irrigation water. This unqualified prescription fails to take into account that many of the chemicals are contaminants to only selected crops. A more detailed prescription

Table 4b Wastewater re-uses criteria of Arizona, California and Nevada.

| Use category | Parameter | Arizona | California | Nevada |
|---|---|---|---|---|
| unrestricted urban reuse, agricultural reuse: food crops, unrestricted recreational reuse | BOD5 (mg/I) | not specified | not specified | 30 |
| | turbidity (NTU) | average 2; maximum 5 | average 2; maximum 5 | not specified |
| | fecal coliform (MPN/100 ml) | average: not available; maximum 23 | not specified | average 2.2; maximum 23*; average 200; maximum 400¤ |
| | total coliform (MPN/100 ml) | not specified | average 2.2; 30-day maximum 23 | not specified |
| restricted urban reuse; nonfood crop irrigation; restricted recreational reuse | BOD5 (mg/I) | not specified | not specified | 30 |
| | fecal coliform (MPN/100 ml) | average 200; maximum 800 | not specified | average 23; maximum 240Ƨ; average 200; maximum 400© |
| | total coliform (MPN/100 ml) | not specified | average 23; 30-day maximum 240#; average 2.2; 30-day maximum 23** | not specified |

*Apply to unrestricted urban and recreational reuses.
¤Apply to agricultural reuse—food crops.
Ƨ Restricted urban and recreational reuses.
©Agricultural reuse—nonfood crops.
#Apply to restricted urban reuse and agricultural reuse—nonfood crops.
** Restricted recreational reuses
**Source**: Division of Agriculture and Natural Resources (ANR), University of California USA.

would avoid the present treated wastewater waste.

The agronomic standards include salinity, sodium absorption ratio, and specific ion toxicity of sodium, chloride, boron, and trace elements affecting sensitive crops. Normally, domestic wastewater (excluding industrial wastes, or with proper treatment of industrial wastewaters) does not contain chemical contaminations in excess of the allowable limits for agricultural irrigation.

### The standards of wastewater re-uses and discharges in several states of the USA

Standards adopted in Arizona, California and Nevada is used for comparison purpose because they are somehow similar to KSA environment. The author of this article has driven across those states several times and visited several cities there. He felt that those three states have similar nature and climatic environment (e.g. cactus is there) like KSA Arizona, Nevada and California recommend secondary treatment and disinfection for restricted urban reuse (Table 4b).

Table 4b shows different standards for different treated wastewater reuses. It discriminates between restricted and unrestricted urban and recreational reuses; food, and non-food crops. The table also shows that there are differences in standards among those three states. These standards were also developed according to the exposure to the wastewater and certain localities of the states.

Unfortunately, in Saudi Arabia, a small amount of treated wastewater is used. Table 3 shows the amount of the treated wastewater used in Saudi Arabia is 3,454,071 $m^3$/d. This means that a considerable quantity of treated wastewater is being discharged, into the Red Sea or into the Gulf or into Wadis, unused. It can be re-used safely in many other uses, if the standards are not so stringent.

In Table 4c (NMED, 2007) reclaimed waste water was divided into 4 classes. Each class as defined in table 4c (footnotes) is for certain uses, access and exposure to the public. The table shows that the average 30 days and the maximum allowable limit for $BOD_5$ and TSS (except class 1a) range from 10 to 45 mg/l and from 30

Table 4c Wastewater Quality and Monitoring requirement in New Mexico.

| Class of Reclaimed Wastewater | Wastewater Quality Parameter | Wastewater Quality Requirements | | Wastewater Monitoring Requirements | |
|---|---|---|---|---|---|
| | | *30-Day Average* | *Maximum* | *Sample Type* | *Measurement Frequency* |
| Class 1A | $BOD_5$ | 10 mg/l | 15 mg/l | Minimum of 6-hour composite | 3 tests per week for major WWTP[1]; 1 test per 2 weeks for minor WWTP |
| | Turbidity | 3 NTU | 5 NTU | Continuous | Continuous |
| | Fecal Coliform | 5 per 100 ml | 23 per 100 ml | Grab sample at peak flow | 3 tests per week for major WWTP; 1 test per week for minor WWTP |
| | TRC or UV Transmissivity | Monitor Only | Monitor Only | Grab sample or reading at peak flow | Record values at peak hourly flow when Fecal Coliform samples are collected |
| Class 1B | $BOD_5$ | 30 mg/l | 45 mg/l | Minimum of 6-hour composite | 3 tests per week for major WWTP[1]; 1 test per 2 weeks for minor WWTP |
| | TSS | 30 mg/l | 45 mg/l | Minimum of 6-hour composite | 3 tests per week for major WWTP[1]; 1 test per 2 weeks for minor WWTP |
| | Fecal Coliform | 100 organisms per 100 ml | 200 organisms per 100 ml | Grab sample at peak flow | 3 tests per week for major WWTP; 1 test per week for minor WWTP |
| | TRC or UV Transmissivity | Monitor Only | Monitor Only | Grab sample or reading at peak flow | Record values at peak hourly flow when Fecal Coliform samples are collected |
| Class 1B | $BOD_5$ | 30 mg/l | 45 mg/l | Minimum of 6-hour composite | 3 tests per week for major WWTP[1]; 1 test per 2 weeks for minor WWTP |
| | TSS | 30 mg/l | 45 mg/l | Minimum of 6-hour composite | 3 tests per week for major WWTP[1]; 1 test per 2 weeks for minor WWTP |
| | Fecal Coliform | 100 organisms per 100 ml | 200 organisms per 100 ml | Grab sample at peak flow | 3 tests per week for major WWTP; 1 test per week for minor WWTP |
| | TRC or UV Transmissivity | Monitor Only | Monitor Only | Grab sample or reading at peak flow | Record values at peak hourly flow when Fecal Coliform samples are collected |
| Class 2 | $BOD_5$ | 30 mg/l | 45 mg/l | Minimum of 6-hour composite for major WWTP; Grab sample for minor WWTP | 1 test per week for major WWTP; 1 test per month for minor WWTP |
| | TSS | 30 mg/l | 45 mg/l | Minimum of 6-hour composite for major WWTP; Grab sample for minor WWTP | 1 test per week for major WWTP; 1 test per month for minor WWTP |
| | Fecal Coliform | 200 organisms per 100 ml | 400 organisms per 100 ml | Grab sample at peak hourly flow | 1 test per week for major WWTP; 1 test per month for minor WWTP |
| | TRC or UV Transmissivity | Monitor Only | Monitor Only | Grab sample or reading at peak hourly flow | Record values at peak hourly flow when Fecal Coliform samples are collected |
| Class 3 | $BOD_5$ | 30 mg/l | 45 mg/l | Minimum of 3-hour composite for major WWTP; Grab sample for minor WWTP | 1 test per week for major WWTP; 1 test per month for minor WWTP |
| | TSS | 75 mg/l | 90 mg/l | Minimum of 3-hour composite for major WWTP; Grab sample for minor WWTP | 1 test per week for major WWTP; 1 test per month for minor WWTP |
| | Fecal Coliform | 1000 organisms per 100 ml | 5,000 organisms per 100 ml | Grab sample at peak hourly flow | 1 test per week for major WWTP; 1 test per month for minor WWTP |
| | TRC or UV Transmissivity | Monitor Only | Monitor Only | Grab sample or reading at peak hourly flow | Record values at peak hourly flow when Fecal Coliform samples are collected |

[1]Wastewater Quality Requirements and Monitoring Frequencies by Class of Reclaimed Wastewater in New Mexico.
Note: *E.* coli may be used in place of Fecal Coliform as an indicator organism, once an equivalency has been established.
Class 1A: the highest quality reclaimed wastewater which can be most broadly utilized except for direct consumption.
Class 1B: the second highest quality reclaimed wastewater which is suitable for uses in which public exposure is likely.
Class 2: suitable for uses in which public access and exposure is restricted.
Class 3: reclaimed wastewater suitable for uses in which public access and exposure is prohibited.
**Source:** Environment Department, New Mexico, USA.

to 90 mg /l respectively. For fecal coliform, the standards range from 5 to 5000 organisms per 100ml. The Table further shows sample types and frequency of measurement needed for each class of reclaimed wastewater. The table also shows that the average 30 day of turbidity should not exceed 3 NTU while the maximum is 5 NTU in class 1a only. The other classes do not specify turbidity. The Table also recommends monitoring for total residual chlorine (TRC) or ultra-violet transmissivity.

The conclusion (Table 4c) is that each class of use requires different standards, sample types and measurement frequencies. Standards for each type of use similar to New Mexico may be set up by the authority for wastewater reclamation.

## Conclusion

- Saudi wastewater reuse and discharge standards are stringent.
- Several wastewater treatment plants in KSA are of secondary level. Their effluent quality does not meet the stringent standards requirements.
- To meet those standards, huge amount of funds are needed to upgrade the existing wastewater plants.
- Wastewater reuses and discharges mostly don’t need such extra stringent standards.
- Standards of wastewater reuses/discharges adopted in Arizona, Nevada California and New Mexico are used for comparison purposes with KSA because they are somehow similar to KSA environment.
- Related data of USA states show restricted and unrestricted urban and recreational reuses; food, and non-food crops. These states adopted several sets of standards which depend upon the type of the reuse and the discharge.

The article suggests setting up standards for each type of reuse/discharge in KSA.

## Recommendations

### Primary Recommendations

- Saudi standards for wastewater treatment, discharges, and reuses require extensive expansion and revision to make them useful for pollution control. Economic, environmental, and social aspects should be taken into consideration. Saudi localities of every respect should be involved.
- The studies should involve soil bearing capacity for heavy metals. Land uses, type of grass which animals subsist on, and animals raised for milk, meat, wool, skin, etc., should also be studied. To protect the natural water resources, it is necessary to carry out an intensive study on the potable water aquifers to identify the optimum locations of the discharging points of treated wastewater. Another important point is to carry out the required geological marine studies to identify the optimum locations of marine outfalls to protect the marine environment and the coastal areas.
- Standards and regulations for the following reuses/discharges should be set up:

i Discharge into seawater through a marine outfall.

ii Discharge into bays along the seashore.

iii Discharge into wadis with non-potable groundwater.

iv Discharge into wadis with groundwater as current or future drinking water sources.

v Restricted irrigation e.g.: green areas along streets and medians in highways (land scaping).

vi Restricted agricultural irrigation of non-edible crops like cotton, tobacco, etc.

vii Restricted agricultural irrigation of fodder, fiber and seed crops, and processed foods.

viii Unrestricted agricultural irrigation of foods consumed uncooked such as lettuce.

ix Unrestricted irrigation, e.g., public and private gardens and parks (recreational).

x Unrestricted agricultural irrigation of food consumed cooked such as beans, okra, gourds, etc.

xi A specific standard should be set up for irrigation of palm trees that are tall. Dates are widely consumed as food and source of nutrition for people in the Kingdom. There are approximately 20 million palm trees in Saudi Arabia.

- It is imperative that local experts in environmental science, social science, economics and public health be involved in these studies so that they can contribute, in recognition of both the independence and interrelatedness of these factors.
- Standards and their specifications would have to be periodically updated and a mechanism for monitoring treatment activities needs to be developed.
- Standards will not function in an effective manner unless sampling, analysis, reporting and any other related aspects are technically and properly handled and managed.

- Enforcement of the implementation of all standards, specifications, and regulations should be practiced, and an authorized Ministry/Authority should be appointed.

- The control authority should establish the legal authority, framework and procedures necessary to ensure that the standards and their specifications are complied with.

- Composite samples should be collected beside grab samples (as needed), since each has its own purpose and function.

- Wastewater which does not meet the standards of the public wastewater system should not be allowed to be connected to the public sewer system or discharged into wastewater treatment plants. Pre-treatment of such wastewater should be carried out before discharging into the public sewerage system.

**Secondary Recommendations**

- Until suggested studies are completed and new standards are set up, World Health Organization (WHO) standards for treated wastewater discharges, and reuses may be used, followed, and practiced.

- There should be a closer organizational collaboration among MA, PME, MMRA and MP (Ministry of Planning) for publication of joint standards.

- Every effort should be made to complete public water network in all urban areas. This will enable the officials to control and well manage the municipal water in all residential and commercial sectors. This will also make it possible to make sure that the tap water meets the drinking water standard. Tankers should be stopped as soon as possible because the source from where they draw the water is not always known.

- Every effort should also be made to keep the water continuously feeding the public water network in the urban areas. Feeding the public water network in the urban areas should not be intermittent because when the water is under pressure, groundwater will not infiltrate the public water network. This will also save a lot of money because ground and elevated water tanks in the residential and commercial units will not be needed any more. Therefore, considerable financial saving is possible.

- For the same arguments, the sewerage system must be completed as soon as possible because the absence of it has some negative consequences. Also, wastewater cannot be collected, treated and reused.

- Every effort should be made to prevent wastage of treated wastewater. It should be remembered that the KSA is an arid land where water is precious.

- Septic tanks rather than cesspits should be used as a sanitary disposal system. Their configuration, location, and distance from any water supply or groundwater tank storage, should be specified from the engineering point of view.


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- Presidency of Meteorology and Environment (PME), Riyadh, Saudi Arabia. (http://www.p me.gov.sa/en/eindex.asp).

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