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SUSTAINABLE MANAGEMENT OF DOMESTIC WATER RESIDUES AND DIMINUTION OF DISCHARGES INTO MUNICIPAL COLLECTORS IN MEXICO

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Abstract
This work is a study on the sustainable management of water according to the regulation and recommendations of sustainable architectural design of the environmental model by LEED® (Leadership in Energy and Environmental Design), particularly in respect to the adequate management of household residual water discharge into the municipal collectors. The study lays the bases to decrease the volume of residual water discharge into municipal collectors, which brings along many benefits of the environmental, social and economic kinds in the place where it is applied. A case study for the municipality of Metepec, State of Mexico, Mexico, will be approached; firstly, carrying out a diagnosis of wastewater discharge from buildings in the municipality to learn the volumes that are generated in order to run a study on the diminution of said residues into the collectors, hence decreasing the discharges allowed for at Federal level. This work might be used as an instrument by the different sectors of public administration in Mexico, mainly the municipal governments, in charge of water management, as well as designers, urbanists, architects and those in charge of designing human settlements of any kind.
Keywords: water discharge, municipal waste, pollution, sustainable urbanism.

1. INTRODUCTION

In recent years, the housing sector in Mexico has experienced an unseen growth, sharp and conspicuous; nowadays there are 106.7 million people in Mexico, who represent a heavy pressure on housing necessities. It was estimated that in 2004 the country needed 707 273 new households (CONAFOVI, 2004); and from this total, around 50% corresponded to self-construction and the other half to real estate developments. In the aforementioned period, ninety percent of the new households was concentrated on the Rural-Minimal, Social and Economic categories; conversely, this sort of households only represents 61.3% of the construction value (CIDOC, 2005). According to consulted data, in 2010 the country will experience the highest demand for housing (CIDOC, 2005). The importance of water and sanitation facilities has been reflected in the measurement of human development and in their inclusion in Millennium Development Goals (MDGs) , particularly in countries in process of development (Sanusi, 2010).

The State of Mexico is one of the most densely populated and economically active of the country; because of this, strategic developments of housing zones have appeared. One of these strategies consists in concentrate exclusively for mass housing areas, but such area reflects the pressure of the city on the surrounding neighbouring space (Avram, 2009) observed in others countries in the world; usually, cities are characterized because they are often fragmented randomly and generate several problems of urban development, particularly in the housing (Alabi, 2009) . Only in the municipality of Metepec, State of Mexico, it is estimated that between 2015 and 2020 there will be a demand for 3886 new households, which will occupy 182.4 ha, of which 23.22 ha will be destined for social progressive and popular housing, with permitted plots between 100 and 167 square meters, as well as:

- 29.57 ha for popular housing with plots of 210 m²
- 53.52 ha for intermediate housing with plots between 500 and 583 m²
- 76.63 ha for residential housing with plots of 833 m² of gross surface
- 108.88 ha for high residential housing with plots of 1, 667 m²

TABLE 1 - TOTAL HOUSING REQUIREMENTS ACCORDING TO TYPE, 2010-2015; PROSPECTIVE SCENARIO FOR THE MUNICIPALITY OF METEPEC, STATE OF MEXICO.

Type	Population	%	Households	Gross surface (ha)
Social progressive or popular housing (H100A, H167A)	5, 481	22.32	1, 237	24.74
Popular (H417A)	4, 192	17.07	946	31.51
Mid (H500A, H583A))	5, 053	20.58	1, 141	57.03
Residential (H833A)	3, 617	14.73	817	8165
High residential (H1667A)	2, 570	10.47	580	116.03
Total	**20, 914**	**85.16**	**4, 141**	**194.95**

Source: INEGI, (2005) census.

There being a sharp demographic growth and higher housing demand, a better infrastructure and services are needed, namely: potable water, electricity, waste management, such as solid waste collection, sewer systems, wastewater and urban runoff collectors. Regarding water as the *par excellence* vital resource, we face a somber panorama if we have no considerations to take care of it.

According to CONAGUA by 2025, Mexico and several Latin American countries will confront a crisis due to shortages acuter than those currently occurring.

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In the city of Metepec, we see that the fast demographic growth has caused insufficiency in potable water distribution; on the other side, the collectors are surpassed in their capacity as urban runoff is added to sewage. As for sewerage, drainage and wastewater treatment, Metepec has discharge permission (08MEX105924/12HAGE99) to pour wastewater to federal water bodies (in this case Lerma River), up to a yearly volume of 10 969 054.10 m^3; this permission expires soon, and now the municipality is carrying out steps in National Commission of Water (*Comisión Nacional del Agua*) to modify it because of the urban growth; an increment to 13 438 802.75 m^3/year is expected (H. Ayuntamiento de Metepec, 2009), so the present work shows some solutions for said problem, specifically to save water and pour lower amounts of wastewater into the municipal collectors. As a consequence of these planned projections, different organizations devoted to housing have agreed, inside the 2001-2006 Sectorial Housing Program of CONAFOVI, on a Program of *Sustainability in Housing*, which has a general objective to develop a Program of Sustainable Housing that allows having better quality in the households, offering comfort and health, and guaranteeing the protection of the Environment and Natural Resources, specifically water (CONAVI, 2010).

In accordance with the 2005-2011 Plan of Urban Development of the State of Mexico (*Plan de Desarrollo Urbano del Estado de México 2005-2011*) (Gobierno del Estado de México, 2005) in Part 2 referring to Sustainable Development, Chapter I: Environmental Sustainability for the Development of Life, defines the following strategies and action lines:

- Guarantee the application of the instruments of environmental policy as efficacious tools to promote public and private development projects, congruent with the preservation of the environment.
- Promote an environmental alliance with all the municipalities, productive sectors, academic institutions and civil society organizations in the state to consolidate the culture of environmental protection by means of education, training, and diffusion of environmental policy.
- Agree with the academic institutions and productive sectors in the State of Mexico on the mechanisms to foster and promote environmental research and the use of the most suitable technology in the productive processes.

Then according to this last entry, the participation of research to generate proposals related to technology which helps to alleviate the problem of wastewater in Metepec is of the utmost importance for the state development, in this case helping develop both sustainable management of water and the infrastructure for it.

2. SUSTAINABLE ARCHITECTONIC DESIGN RECOMMENDATIONS FOR WATER MANAGEMENT ACCORDING TO LEED® ENVIRONMENTAL MODEL (U.S.) AND URBAN LEVEL RECOMMENDATIONS OF THE CODE OF HOUSING CONSTRUCTION BY CONAVI (MEXICO)

We, the architects, urbanists and promoters of cities and buildings, have a number of tools to design, plan, maintain and build urban infrastructure using *sustainability* criteria; one of them is the environmental method to design and equip buildings called LEED®, Leadership in Energy and Environmental Design (LEED, 2008). The other tool, for the Mexican case, is the Code of Housing Construction (CEV), issued by the National Commission of Housing of the Government of Mexico (CONAVI, 2010). The environmental model of design and construction (LEED®) has 5 categories of natural resource sustainable management from design and construction process to use, operation, maintenance and end of lifecycle of the building; one of such categories is water sustainable management in buildings and proposes some design strategies to save and decrease water use, as well as better use, treatment and alternatives for residual discharges. Indeed in this last point is where the present study approaches some alternatives to better use water inside the buildings, causing thereby a reduction of the discharges into municipal collectors, directly reducing the environmental impact on water resources, and indirectly decreasing energy use for pumping and supplying water at municipal level; although we will only approach the benefits of sustainable management referring to water, it is important to underscore that there are also benefits for the environment via reduction of energy consumption.

We now summarize the main *strategies* by LEED® which may be used in a problem where the use of water in buildings is not adequate, therefore large flows of water, which might be significantly reduced, are discharged into the wastewater collector.

Strategies of sustainable design and water management in buildings:

- Reduction of water losses from installations, accessories and their maintenance.
- General reduction in the consumption of buildings and accessories inside them; for instance: installing saving sinks, toilets, showers, etc.
- Search for alternative sources of water supply, such as catchwater, and pluvial collection from the roofs.

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- Recollection of rainwater in alternative reservoirs to avoid discharging it into the sewer system; as well as direct recharge of aquifers without being polluted with wastewaters.
- Responsible use and reuse of water; for instance the use of gray waters for certain applications, treatment of residual waters, etc. this will be directly determined by the sort of construction, and each will be responsible for the use and recycling of water as much as possible. When applicable, the costs of water shall be adjusted in accordance with the use given to it, for instance: in industrial activities the used volumes are large and in general there is not a coherent base to determine its price, neither are industries obliged to recover, at least, a percentage of the employed and contaminated water, many a time so polluted that its treatment and recycling become unrealizable; therefore, higher there should be the charges for the ones who pollute the most.
- Another resource which might be implemented to protect water is to create incentives for families and enterprises that install water treatment plants; which recycle and reuse water and also reduce water consumption in their buildings. Incentives which may be tax reductions generated by water and sewer, funding programs to secure potable water systems and sewerage, etc.

Particularly for the case of the stated issue of residual water discharge into municipal collectors, we may consider:

1. General reduction in water consumption from furniture and accessories in the buildings (for instance, replacing sinks, toilets and showers).
2. Use and reuse of gray waters, treated or untreated, in applications where potable water is not essential.
3. Recollection of rainwater in alternative collectors to avoid pouring them into the sewerage; as well as direct recharge of aquifers without being polluted with residual waters.

These are strategies where several sorts of technologies and eco-techniques might be used to reach the goals; technologies such as gray water treatment systems, water-saving equipment and accessories, systems to collect rainwater and to recharge aquifers.

On the other side, there are also recommendations by CONAVI to save and ecologically manage water in buildings and urban development (CONAVI, 2010). Said recommendations can be summarized as follows:

- Supply quality water, either natural or treated, which complies with the environmental technical regulation.
- Adequate distribution, inspection and supervision of the pipe network.
- Technologies to save water (flowmeters, showers, toilets, sinks, etc.).
- Recharge via direct reinjection or treated residual water into aquifers.

And from the technical recommendations to sustainably manage water by CONAVI, we would use for the problem stated here the following:

1. Direct reinjection of residual treated water into the aquifer (equivalent to 3 in the recommendations taken from LEED®).
2. Technologies to save water (which is the same as 1 in LEED® model).

We now analyze the Mexican Official Norm as for water quality, both for supply and discharge into municipal collectors.

3. MEXICAN REGULATION OF RESIDUAL WATER DISCHARGE INTO MUNICIPAL COLLECTORS (NOM-002-SEMARNAT-1996) (SEMARAT, 1996)

The quality of potable water is controlled according to AA-149/2-SCFI-2008 CONAGUA norm; this regulation states that potable water must be suitable for direct human consumption according to the local requirements of potability, independently from the uses it may have once delivered. Efforts are carried out to achieve this quality at all times, which is the general expectation. Besides, its supply for human use and consumption is regulated by the MEXICAN OFFICIAL NORM, NOM-181-SSA1-1998, ENVIRONMENTAL HEALTH; WATER FOR HUMAN CONSUMPTION. SANITARY REQUISITES THAT GERMICIDES MUST COMPLY WITH TO TREAT DOMESTIC WATER, where it is specified that said consumption must have high quality to prevent and avoid the transmission of gastrointestinal diseases, as well as others, for which permissible limits must be established in relation to its bacteriologic, physical, organoleptic, chemical and radioactive characteristics.

In views of securing and preserving the quality of water in the systems, until deliverance, it must undergo treatments to make it potable.

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Permissible limits of bacteriologic characteristics

The content of organisms from the analysis of a simple water sample must be adjusted to the parameters in Table 2.

TABLE 2 - PERMISSIBLE LIMITS OF BACTERIOLOGIC CHARACTERISTICS

CHARACTERISTIC	PERMISSIBLE LIMIT
Total coliform organisms	2 MPN/100 ml 2 CFU/100 ml
Fecal coliform organisms	Undetectable MPN/100 ml Zero CFU/100 ml

Source: CONAGUA (2008) Norm (NMX-AA-149/2-SCFI-2008).

The results from the bacteriologic analysis must be reported in MPN units (most probable number per 100 ml) if the MPN technique is used; or CFU/100 (colony-forming units per 100 ml) if the membrane-filtration technique is used.

Treatments to make water potable

Making water from a particular source potable must be justified with quality studies and treatment probes at laboratory level to guarantee their effectiveness.

The following specific treatments, or those resulting from the treatment probes, must be applied when the microbiological pollutants, physical characteristics and chemical constituents of the water exceed the established permissible limits listed below.

TABLE 3 - PERMISSIBLE LIMITS OF CHEMICAL CHARACTERISTICS, EXPRESSED IN MG/L.

CHARACTERISTIC	PERMISSIBLE LIMIT
Tin	0,20
Arsenic (Note 2)	0,05
Barium	0,70
Cadmium	0,005
Cyanides (such as CN-)	0,07
Free residual chlorine	0,2-1,50
Chlorides (such as Cl-)	250,00
Copper	2,00
Total chrome	0,05
Total hardness (such as CaCO3)	500,00
Phenols or phenolic compounds	0,3
Iron	0,30
Fluorides (such as F-)	1,50

CHARACTERISTIC	PERMISSIBLE LIMIT
Aromatic hydrocarbons in micrograms/l:	
Benzene	10,00
Ethylbenzene	300,00
Toluene	700,00
Xylene (three isomers)	500,00
Manganese	0,15
Mercury	0,001
Nitrates (such as N)	10,00
Nitrites (such as N)	1,00
Ammoniacal nitrogen (such as N)	0,50
pH	6,5-8,5
Pesticides in micrograms/l:	
Aldrin and dieldrin (separate or combined)	0,03
Chlordane (isomer total)	0,20
DDT (isomer total)	1,00
Gamma-HCH (lindane)	2,00
Hexachlorobenzene	1,00
Heptachlor and heptachlor epoxide	0,03
Methoxychlor	20,00
2,4 – D	30,00
Lead	0,01
Sodium	200,00
Total dissolved solids	1000,00
Sulfates (such as SO4=)	400,00
Methylene-blue active substances (MBAS)	0,50
Total trihalomethanes	0,20
Free residual iodine	0,2-0,5
Zinc	5,00

Source: CONAGUA (2008) Norm (NMX-AA-149/2-SCFI-2008).

As for the limits of residual discharge, it is regulated by the CURRENT MEXICAN OFFICIAL NORM REGARDING RESIDUAL WATER DISCHARGES, NOM-001-SEMARNAT-1996 (SEMARNAT, 1996).

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4. METHODOLOGY

The problem, for the case of Metepec, State of Mexico, Mexico, is that large volumes of residual waters are poured into municipal collectors and it is needed to cut down these amounts, since all the municipalities have discharge limits (in cubic meters) allowed at federal level by the organisms responsible for administrating water in Mexico; as well as by the necessity to reduce environmental impacts caused by the waste and pollution of the water distributed in the cities. In this work in particular, it is proposed to reduce residual water discharge through the diminution of water use at the households, which are the most common sort of buildings in any city; for this we will take three sorts of strategies from the ones by LEED® and those by CONAVI, and they are:

1. General reduction in the consumption of furniture and accessories in the buildings (for instance replacing water-saving sinks, toilets, showers, etc.).
2. Use and reuse of untreated gray water for non-potable water uses.
3. Do not mix rainwater and wastewater in the municipal collectors; supply exclusive collectors for rainwater and directed at recharging the aquifers in the city.
4. Direct a percentage of rainwater for domestic uses.

In order to achieve these objectives, firstly the number of households in the selected municipality or city will be studied, and an average number of users in each household will be defined; then we will calculate the average consumption of water per user, so that we can calculate the total use of water for the household. Once we have these data we will carry out a study of a typical household where the proposals or strategies to save water will be applied, calculating a significant saving per user, thereby in the household; consequently, the discharges of residual water into the collectors will be cut down. The final measuring unit will be the cubic meters of saved residual water.

It is worth mentioning that this is a study where we will estimate the diminution of residual water discharges in an approximate manner, as a typical household, according to INEGI, will be taken; it is not a detailed study to obtain data per sort of household users; since many data would be qualitative, subjective and by uses and customs of the dwellers which would make them not 100% quantitative and reliable.

5. CASE STUDY FOR THE DIMINUTION OF DISCHARGES INTO THE MUNICIPAL COLLECTOR OF METEPEC, STATE OF MEXICO, MEXICO.

Quantitative data:

Case study: City of Metepec, State of Mexico.

Numberof households: 2 197 households (Census of Population and Housing, INEGI 2005).

Average number of household members: 4.9 (Metepec Development Plan, State of Mexico, 2009-2012)

Recommendation for average water consumption per dweller, according to Mexico City Construction Regulation (*Reglamento de construcciones del Distrito Federal*) (2010): 200 liters a day per dweller.

Average daily water consumption per user: 200 liters a day.

Average water household consumption: 980 liters a day.

Average consumption in Metepec by intermediate household: 2 153 060 liters a day.

Yearly average water consumption in Metepec by intermediate household: 2 153 060 (365 days) = 785 866.9 m³.

Sort of household: residential (H833A).

Strategies to reduce use of water and discharges into municipal collectors:

Strategy 1 — General reduction of furniture and accessories in the buildings (installing water-saving sinks, toilets and showers).

This represents water saving with trademarks currently found in the market, it is estimated that 56% of regular consumption per household member.

In the following table, we see the values of water consumption, by means of which the average of 56% is determined. By means of different measures or modifications (such as the use of water-saving taps (level 1), use of modern domestic appliances, washing machines, dishwashers, etc., (level 2), use of rainwater (level 3) or recycling gray waters) a considerable potential of saving is attainable without influencing the quality of the service.

Table 4 shows the uses of water where by means of saving techniques, the excessive consumptions of water can be reduced.

It is relatively simple to save water in the following devices:

- In faucets
- In showers
- In toilet cisterns

TABLE 4. VALUES OF WATER CONSUMPTION PER ITEM OF FURNITURE AND ACCESSORIES

Activity	Use of conventional technique (level 1)	Use of additional devices (level 2)	Additional use of rainwater (level 3)	Additional use of recycled gray waters (level 4)
Personal care	35(75%)	23(50%)	23(50%)	23(50%)
Toilet (WC)	30(75%)	20(50%)	4(10%)	0(0%)
Clothes	15(90%)	13(75%)	4(25%)	2(10%)
Tableware	7(90%)	6(75%)	6(75%)	6(75%)
Food/drink	3(100%)	3(100%)	3(100%)	3(100%)
Cleaning	6(100%)	6(100%)	6(100%)	6(100%)
Garden	3(100%)	3(100%)	1(25%)	0(0%)
Other	5(100%)	5(100%)	5(100%)	0(0%)
Total	104(81%)	79(62%)	52(41%)	40(31%)

Source: Helvex catalogue, 2010.

TABLE 5. REDUCTION OF COSTS THROUGH WATER SAVING

Water saving	Shower	Sink	Toilet	Total
Use per person a day	3 minutes	2,5 minutes	4 flushes	-
Use of conventional technology	20 L/min	15 L/min	10 L/flush	-
Water consumption per person a day	60 liters	37,5 liters	40 liters	-
Annual consumption (c. 333 days)	19,8 m³	12,4 m³	13,2 m³	45,4 m³
Energy consumption (hot water)	600 kW	370 kW		-
Saving potential	50%	40%	50%	-
Amortization period	3 months	2 months	5 months	-

Source: Helvex catalogue, 2010.

This is to say, currently the water discharge in Metepec from the households is 2 153 060 liters a day, a 56-percent saving in the regular consumption per inhabitant would become 1 205 713.5 liters a day, and the annual volume would reach (1 205 713.5 x (365 days) = 440 085 427.5 / 1000 = 440 085.4 m³.

Saving with strategy 1 = 440 085.4 m³

So the allowed discharge of residual waters into the municipal collectors is considerably reduced.

Strategy 2 — Use and reuse of untreated gray waters for non-potable domestic use.

The daily water consumption per user in a typical intermediate household is distributed as follows (Enríquez, 2000):

1. Bath / shower 60 liters/day
2. WC 46 l/d
3. Sinks 10 l/d
4. Personal hygiene 10 l/d
5. Kitchen and drink 6 l/d
6. Other 8 l/d
7. General cleaning 12 l/d
8. Garden watering 23 l/d
9. Washing 25 l/d

Nowadays the water discharge in Metepec in the case under study referred to intermediate households is 2 153 060 liters a day; if we consider the use of gray waters in showers and sinks, we would have a total of 70 liters per person a day, multiplying this by 4.9 people on average, it tallies 343 liters a day which would be saved using this strategy.

(343 liters) x (2 197 households) = 753 571 liters a day of reuse water

Annual: 275 053.415 m³.

So the allowed discharge of residual waters into the municipal collectors is considerably reduced.

Saving with strategy 2 = 275 053.415 m³

Strategy 3 — Do not pour rainwater into the residual water municipal collectors

This is aimed at recharging the aquifers in the zone; considering that in Metepec, there is a yearly rainfall of 900 mm, from this volume only a minimal percentage would reach the general collector. And considering the 25-percent donation, as stated by *Mexico City Construction Regulation* to recharge aquifers, the saving would be as follows:

An approximate extension of 120 m² per intermediate household, multiplied by 2 197 counted households are 263, 640 m² of land extension, so 25% of the area to allow rainwater filtration is 65 910 m², therefore the cubic meters of rainwater would be 59 319 m³, which would reach the aquifers.

Saving with strategy 3 = 59 319 m³

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6. CONCLUSIONS

The sustainable management of water resources by means of strategies and lineaments of architectural design from LEED® environmental model allows the city of Metepec to have an adequate management of said resources, and with it to control their discharge into the municipal collectors.

The strategies stated in this work will yield benefits as they considerably decrease the volume of residual waters with environmental, economic and social advantages in the place, if they are set up.

With strategy 1, this is installing commercially available saving sinks and furniture, Metepec will have considerable savings in discharge.

TABLE 6 - SUMMARY OF WATER SAVINGS BY STRATEGY

Strategy	Current flow of water poured into the municipal collectors, in intermediate households	Saving
1	785 866.9 m³	440 085.4 m³.
2	785 866.9 m³	275 053.415 m³.
3	785 866.9 m³	59 319 m³
Total:		774 457.8 m³.

NB. The total increases considerably because in strategy 2 the yearly volume of reutilized gray waters is included.

Moreover, if the RULING MEXICAN OFFICIAL REGULATION ON RESIDUAL WATER DISCHARGE NOM-001-SEMARNAT-1996 (SEMARNAT, 1996) is considered, it mentions that the problem is not the discharge in cubic meters, but the basic pollutants, heavy metals and cyanides said discharge contains, so other strategies would be applicable, such as treatment of residual water, which was not considered in the present study.

Of all the strategies presented here, strategy 2 is the one which achieves a larger volume of saved water, thus yielding a considerable reduction of residual water into the collectors (see table 6).

Strategy 3, which is directed to recharge the aquifers, presents a great contribution regarding to ecology; not only because its environmental benefits, but also because of the economic savings, since with it we would preserve architectural and urban works, consequently the social security of the inhabitants of Metepec.

Separately, according to CONAGUA:

A yearly amount of 13 438 802.75 m³ of residual water is the total discharge allowed into municipal collectors, currently waiting for approval at federal level for the 2009-2012 period; by means of these strategies it would be guaranteed not to surpass the authorized discharge limits (10 969 054.10 m³) as well as those to be authorized.

REFERENCES

Alabi, M.O. (2009). Urban sprawl, pattern and measurement in Lokoja, Nigeria, *Theoretical and Empirical Researches in Urban Management*, 4(13), pp. 158-164.

Avram, S. (2009). The position of rural-urban fringe in the framework of human settlement system, *Forum geographic*; Year 8, N° 8, pp. 139-145.

CIDOC (2005). *Estado actual de la vivienda, 2005*, Centro de Investigación y Documentación de la Casa, Mexico.

CONAFOVI (2004). *Necesidades de vivienda en México 2001–2010*, Comisión Nacional de Vivienda, Mexico.

CONAGUA (2008). *Norma Oficial Mexicana CONAGUA NMX-AA-149/2-SCFI*-2008, Comisión Nacional del Agua, Mexican Government.

CONAGUA (2010). *Programa de agua potable, alcantarillado y saneamiento*, Comisión Nacional del Agua, Mexico. Retrieved from www.cna.gob.mx.

CONAVI (2010). *Código de Edificación y Vivienda CEV*, Comisión Nacional de Vivienda, Mexico.

Enríquez, H.G. (2000). *ABC de las instalaciones de gas, hidráulicas y sanitarias*, editorial LIMUSA, Mexico.

Gobierno del Estado de México (2005). *Plan de Desarrollo Urbano del Estado de México*, Edo. México, Mexico.

H. Ayuntamiento de Metepec (2009). *Plan de desarrollo municipal 2009-2012*, Gobierno del Estado de México, Mexico.

INEGI (2005). *Censo de Población y Vivienda en el conteo 2005*, Instituto Nacional de Estadística, Geografía e Informática, Mexican Government.

Leadership in Energy and Environmental Design [LEED]. (2008). *LEED™ NC- Version 2.1, United States of America,* p. 44, Green Building Council, USA.

Sanusi, Y. A. (2010). Water, sanitation and human development in urban fringe settlements in Nigeria, *Theoretical and Empirical Researches in Urban Management*, 8(17), pp. 14-29.

SEMARNAT (1996). *Norma Oficial Mexicana NOM-001 SEMARNAT-1996,* Secretaría de Medio Ambiente Recursos Naturales, Mexican Government.

SEMARNAT (1996). *Norma Oficial Mexicana NOM-002 SEMARNAT-1996,* Secretaría de Medio Ambiente Recursos Naturales, Mexican Government.