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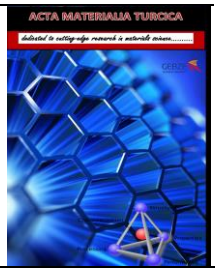

Wastewater Treatment: Overview, Types, Energy Consumption & Actual State in Lebanon with Proposal of Using Renewable Energy

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Abstract:

This paper provides an overview of Wastewater Treatment issue in Lebanon, past, present, and the future. The paper briefs the status of wastewater types adopted in the general study approved by the Lebanese Government to cover the country at the level of design and implementation along with the relevant energy consumption. Accordingly, we shall consider that paper as a recapitulation on exerted efforts by both Government and Council of Development and Reconstruction (CDR) to reach reliable and sustainable wastewater network and wastewater treatment plants. The perspective that we intend as a conclusion is the potential of renewable energy exploitation and treated wastewater reuse assisting the path of autonomy of WWTP's and improvement of the energy management in wastewater treatment based on the integration of renewable energy and biogas.

Keywords: Wastewater Treatment Types; Renewable Energy; Energy; Lebanon Wastewater Treatment Plants (WWTP's); WWTP's Management.

DOI:

1. INTRODUCTION

In many countries and for many years, wastewater remained a serious issue to be addressed to decontaminate communities and protect underground water. 50% of major rivers are seriously polluted [1] at the level of surface and underground pollution of groundwater that has been called a "covert crisis". However, Lebanon tackled this issue after civic war onwards with many measures that count insufficient so far and will be briefed hereunder from different perspectives.

Firstly, we shall shortlist a general overview of wastewater. The characteristics of wastewater can be described as the typical composition of raw untreated wastewater that are solid contaminants, chemical compounds, organic pollutants, inorganic pollutants, pathogens and other pollutants. Knowing the enormous effect of wastewater discharges on the receiving streams, wastewater should be treated to the level of synchronization with the receiving stream water.

As wastewater can contain chemical, biological or physical pollutants making it harmful to use or release back into the environment, treatment became necessary based on the content of wastewater. Many technologies adopted to treat wastewater worldwide yet all fall under Mechanical, Aquatic & Terrestrial. However, all technologies would scatter into physical, biological and chemical treatment techniques accompanied with sludge treatment considered as solid waste treatment. Wastewater usually goes through five different processes that include preliminary, primary and secondary treatments, as well as disinfection (tertiary) and sludge treatment. Most treatment facilities employ similar steps or combine steps when treating wastewater.

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Latest technologies integrated into conventional wastewater treatment based on Reduce, Reuse & Sustain principles are among others desalinization, Biofilm carriers, ultraviolet irradiation, continuous flow intermittent cleaning, membrane fouling filtration technology which uses membrane (at low or high pressure) to remove contaminants from water through ultrafiltration, microfiltration, nano filtration & reverse osmosis.

According to the content of untreated wastewater, treatment should deal with solid waste in water, inorganic compounds constituents including pH, chlorides, alkalinity, nitrogen, phosphorus, sulfur, toxic and heavy metals, & organic matters such as soluble microbial harmful chemicals. The concentration of wastewater is to be measured according to BOD_5 (biochemical oxygen demand) which is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in wastewater at certain temperature over a specific time. Untreated influent BOD_5 is normally 200 to 250 mg/L unless extraordinary conditions [2].

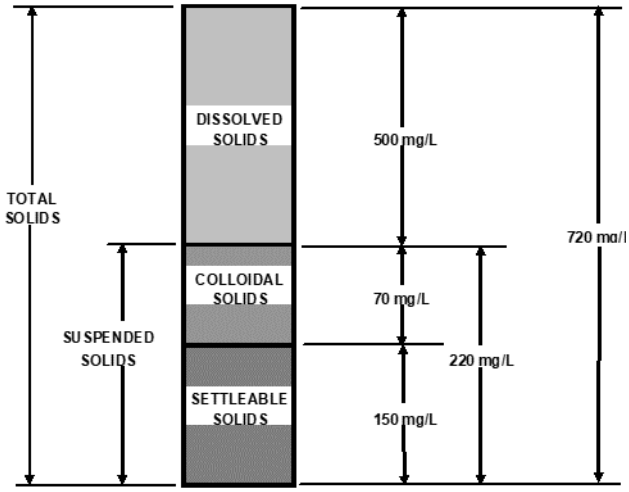

Figure 1. Typical Composition of Solids in Raw Wastewater [2].

Wastewater discharge affects the environment with oxygen depletion and odour in the stream together with negative human health effects along with sludge & foam accumulations.

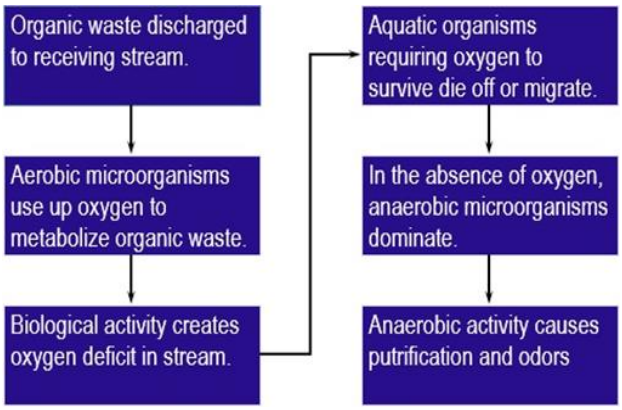

Figure 2: Life Cycle of Organic Waste [2].

Main objectives behind treatment are initially to stabilize wastewater and secondarily to disinfect it. Processes of conventional wastewater treatment are described in the following figure 3.

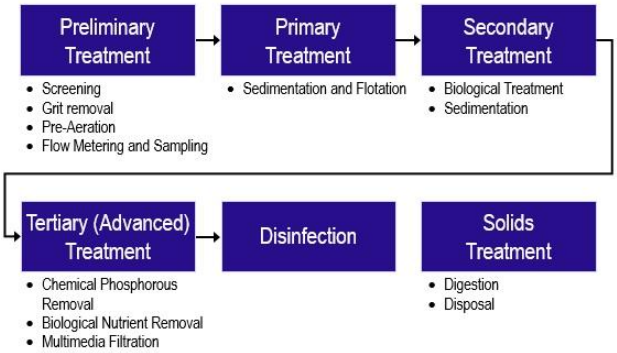

Figure 3. Wastewater Treatment Processes [2].

2. OVERVIEW and TYPES OF WASTEWATER TREATMENT IN LEBANON

Lebanon is a small country located in the Middle East, bordering Mediterranean Sea, Palestine and Syria. Its area 10,452km² amongst 10,230km² of land and 170km² of water. Its coastline lengths 225 km. populated of 6 million residents amongst 2.4 million in Beirut [3].

Lebanon's climate is Mediterranean; mild to cool, wet winter with hot, dry summer. The terrain narrows plainly at coastal line with a Valley in Bekaa separating Lebanon and Anti-Lebanon Mountains. Elevations start with sea level up to 3,087 m. Land use in Lebanon varies between arable lands at 11.9% to agricultural lands at 63.3% amongst 1,040km² only irrigated. Deforestation, erosion,

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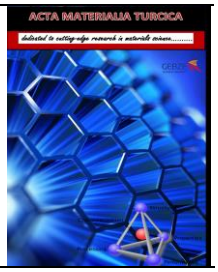

soil deterioration, desertification, air and water pollution; all are environmental issues facing Lebanon despite the affiliation in many international environmental agreements such as Kyoto Protocol. People has access to drinking water at 99% and sanitation facility at 80.7% of population [3].

Table 1. The Electricity status in Lebanon.

Production	17.59 billion kWh
Consumption	15.71 billion kWh
Imports	69 million kWh
Installed generating capacity	2.346 million kW
From fossil fuels	88% of installed capacity
From hydroelectric plants	11% of installed capacity
From renewable sources	1% of installed capacity
Carbon dioxide emissions from consumption of energy	23.36 million Mt.

The difference between production and consumption does not reflect the deficit as many factors intervene to define occurred wastage. In this context, we shall refer to the updated policy paper for electricity sector issued by the ministry of electricity in Lebanon on March 2019 [5].
International consortium for petroleum exploration has been launched in 2019 to extract fossil resources locally.
The government of Lebanon has been active in setting targets for the improvement of the country's energy efficiency and renewable energy capacity through the National Energy Efficiency Action Plan (NEEAP) and the National Renewable Energy Action Plan (NREAP) respectively.

NEEAP pledging an increase in RE exploitation in Lebanon to reach 12% of all energy demand by 2020 by increasing wind energy production to reach 2.06% of energy demand by 2020, second by increasing solar energy production to meet 4.2% of energy demand and increasing biomass use reaching 2.5% of energy demand by 2020. New and existing hydropower plants will meet the remaining renewable energy capacity demand.
NREAP on the other hand, focuses on decreasing future energy demand deliberating multi-sectoral energy efficiency measures amongst wastewater efficiency & operational power [6].

The deteriorated conditions of wastewater network and facilities in Lebanon was the title of this sector until beginning nineties where Lebanese Government and CDR intervention rectified fairly that situation. Big cities were equipped with primitive network yet small communities were lacking both network and facilities. Subsequently, both ground and surface water pollution aggravated with time due to free discharge to sea and rivers and random septic tanks, creating a health-threatening dilemma.
The reason behind that deficiency of wastewater service in Lebanon is the lack of investments by Lebanese Government in this sector along with the absence of convenient management.

Since 1992, the Lebanese Government and CDR (Council of Development and Reconstruction) coped up with the scope of immediate rehabilitation of wastewater sector among others. The followed strategies consisted of urgent renovations of existing wastewater networks and pumping stations, completion of uncompleted projects, full analysis and study of country needs and nature to issue tenders and launch programs protecting Lebanese coasts and water resources from pollution.

However, Lebanon lacked a water code and many decrees at the institutional level to convoy the implementation of any related Law. The only law Lebanon issued concerning water resources and wastewater is the Law No. 221/2000.
Lebanese Government delegated the water and wastewater management and affiliated water utilities to independent public institutions besides the Litani River Authority under the tutelage of the Ministry of Energy and Water. However, without any preparation and rehabilitation, these institutions could not supervise, manage and implement all related wastewater measures and procedures without revealing remarkable deficiencies in wastewater sector management at the national level. Here below is the schematic of completed, ongoing, and under tendering projects as per CDR on 2016.

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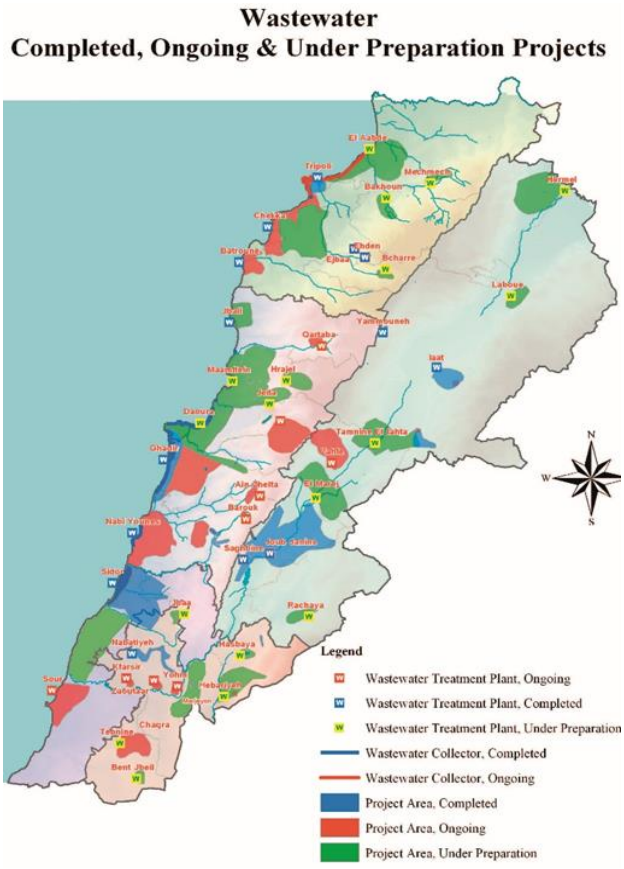

Figure 4. WWT Projects over the Map of Lebanon [7].

At the financial level, Lebanon has allocated versus signed contracts between 1992 and 2015 a total value of $2266.3 million as per CDR progress report 2016 [7].

Table 2. Financial Spending on Wastewater by Lebanese Government from 1992 to 2015 [7].

Total value of contracts awarded from 1992 till 2015 in millions of $				
Sectors	Total Contracts	Contracts In progress	Contracts Completed	Foreign funding
Wastewater	893.31	542.70	350.61	479.68

3. ENERGY CONSUMPTION OF WWTP'S IN GENERAL, IN LEBANON SPECIFICALLY & TRIAL OF BENCHMARKING

Water-energy issues are increasing as much as population is increasing and water shortage is decreasing, attended with higher energy consumption and material cost.

Water and wastewater systems are consuming approximately 3% to 4% of total power consumption of a country [8].

Concerning wastewater, that consumption is generally used for pumping and treating wastewater.

Average power consumption of wastewater treatment plants is between 20 to 45 kWh/(PE•a) and the electrical energy consumption per m³ of wastewater treated would vary between 0.26–0.84 kWh/m³. [9]

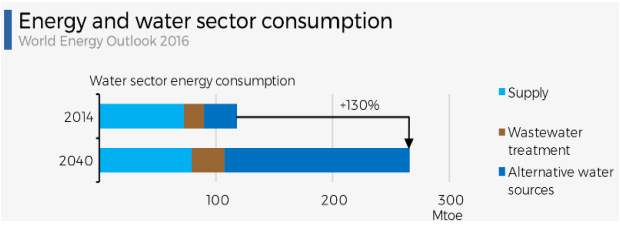

Figure 5. Water Sector Energy Consumption in US by Mtoe [9].

Municipalities should be a major player in water treatment and energy saving/benchmarking processes because these facilities are typically the largest energy consumers, accounting for 30 to 40% of their total consumption. Water and wastewater treatment facilities require significant energy to power pumps, aeration systems, and other operations that we dissect in figure 6 below [10].

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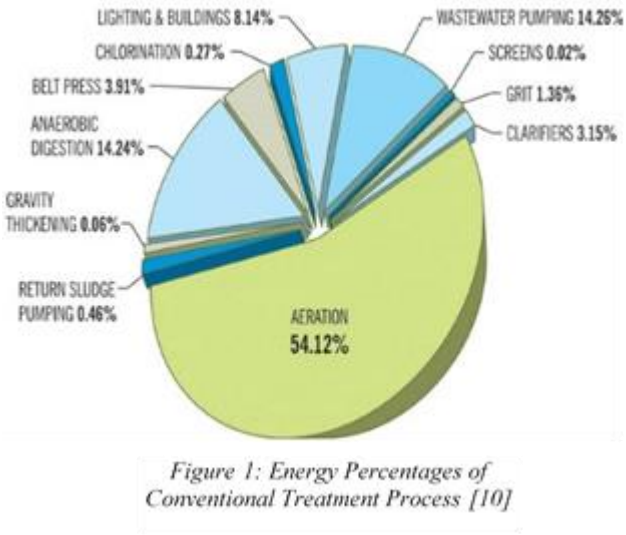

Figure 6. Energy Percentages of Conventional Treatment Process [10].

Below Table & figure, show the breakdown of energy percentage consumption by phase of conventional treatment process:

In Lebanon, the sector of wastewater has no defined energy consumption especially that Lebanon current situation of WWTP's remains related to network conditions and available flow. Consequently, the energy benchmarking can be defined once all plants are fully functional and operational as designed.

4. STATUS OF WWTP'S IN LEBANON

Following previously presented establishment of Lebanese situation in general, we shall present hereunder the accurate situation of WWTP's in Lebanon upon distribution by Caza (Lebanese administrative zoning) and Population Equivalent coverage [12]:

Table 3. Energy Distribution on Treatment Phases [11].

Breakdown of Energy Demand by Equipment				
Equipment	Quantity	Horsepower	Operations	Controls
Mechanical Aerator	1	75	Continuous	Variable Frequency Drive (VFD), manual adjustment
Centrifuge	1	40	10-20 hrs/week	VFD, fixed speed
Influent Pump (No. 1)	1	4.7	Continuous	VFD, speed based on flow
Influent Pump (No. 2 and 3)	2	17.5	Pump No. 2 Continuous Pump No. 3 Back-up	VFD, speed based on flow VFD, speed based on flow
Blowers	3	15	Intermittent	fixed speed
Mixers	3	4	Continuous	fixed speed
UV System	2 banks	7.3(kw)	Continuous	Fixed, 2 banks

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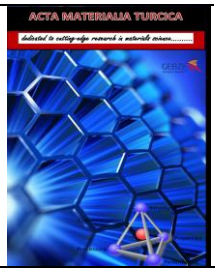

Table 4. Plants under Study or Tendering.

UNDER STUDY / TENDERING			
Treatment Plant	Caza	Equivalent Popuation	Status
Wastewater treatment plants in north			
Aabde	Akkar	250.000	Under final tender stage
Bakhoun	Minieh Dinieh	48.000	Under preparation
Mechmech	Akkar	68.000	Under tendering
Wastewater treatment plants in Beirut and Mount Lebanon			
Keserwan	Keserwan	505.000	Under tendering
Hrajel	Keserwan	40.000	Under tendering
Bourj Hammoud	Baabda-Metn-Beirut	2.000.000	Under preparation
Ghadir (Phase II)	Aley-Baabda-Beirut	1.600.000	Under preparation
Bisri Watershed	Chouf-Jezzine	168.000	Under preparation
Manassef(Dmit and Serjbal	Chouf	94.500	Under preparation
Wastewater treatment plants in north			
Aarkoub	Hasbaya	66.000	Under preparation
Hasbaya	Hasbaya	61.000	Under preparation
Bint Jbeil	Bint Jbeil	37.000	Under preparation
Wastewater treatment plants in Bekaa			
Laboue	Hermel	50.000	Under preparation
Marj – Qabb Elias	Zahleh	300.000	Under tendering
Hermel	Hermel	107.000	Under construction

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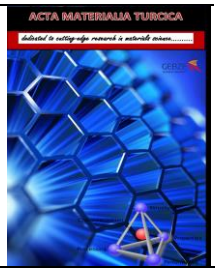

Table 5. Plants under Construction.

UNDER CONSTRUCTION			
Treatment Plant	Caza	Equivalent Population	Status
Wastewater treatment plants in North			
Bcharre & Al Arz	Bcharre	21000	Under construction
Wastewater treatment plants in Beirut and Mount Lebanon			
Kartaba	Jbeil	13000	Under construction
Khenchara	Chouf	30000	Under construction
Wastewater treatment plants in South			
Marjeyoun	Marjeyoun	50000	Under construction
Jezzine	Jezzine		Under construction
Wastewater treatment plants in Bekaa			
Timnine El Tahta	Baalbeck	210000	Under construction

Table 6. Operational Plants showing the phase and status.

OPERATIONAL			
Treatment Plant	Caza	Equivalent Population	Status
Wastewater treatment plants in North			
Tripoli	Tripoli	1.000.000	Pretreatment only
Chekka	Batroun	24.000	Operational since 2017
Batroun	Batroun	30.000	Operational since 2018
Ehden	Zgharta	40.000	Operational since 2016
Wastewater treatment plants in Beirut and Mount Lebanon			
Ghadir	Baabda Aley	1.500.000	Operational (only pre-treatment)
Ras Nabi Younes	Chouf	88.000	Completed
Souayjani & Kafargatra	Chouf	60.000	Operational
Wastewater treatment plants in South			
Salda	Salda	390.000	Only-pretreatment
Nabatieh	Nabatieh	100.000	Operational since 2013
Tibnine	Bin Jibeil	25.000	Operational
Yahmour	Nabatieh	4.500	Operational
Zawtar	Nabatieh	4.500	Operational
Tyr	Tyr	350.000	Completed
Wastewater treatment plants in Bekaa			
Baalbeck / laat	Baalbeck	100.000	Operational
Yammouneh	Baalbeck	6.000	Operational
Zahle	Zahleh	150.000	Operational
Jib Jenine	West Beqaa	78.000	Operational
Saghbine	West Beqaa	4.000	Operational

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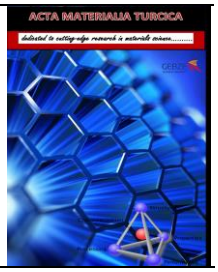

Table 7. Completed Not Operational Plants due to Network Deficiency & Influent Low Flow.

COMPLETED – NOT OPERATIONAL			
Treatment Plant	Caza	Equivalent Population	Status
Wastewater treatment plants in Beirut and Mount Lebanon			
Jbell	Jbell	50.000	Completed not operational
Barouk	Chouf	8.000	Completed not operational
Nabba	Aley	20.000	Completed not operational
Wastewater treatment plants in South			
Kfarsir	Nabatieh	15.000	Completed not operational

5. POTENTIAL OF USE OF RENEWABLE ENERGY AND AVAILABLE RESOURCES

Renewable resources and generation of biogas can reduce conventional energy consumption, cost and GHG emissions. In the case of WWTP's the renewable energy use coupled with the integration of new processes & technologies would contribute in increased treatment efficiency and potential for plants energy autonomy always meeting effluent standards.

At the same national level of wastewater treatment design and analysis, Lebanese Government through CDR and many NGO's programs and projects, the bioenergy had its sufficient part of attention.

UNDP proposed CEDRO project "National Bioenergy Strategy for Lebanon" on 2012 & concluded that municipal sewage sludge potential is 185 Million KWh of Waste-to-Energy. [13]

"Energy from Wastewater Sewage Sludge in Lebanon – Transforming a Waste Disposal Problem into an Opportunity" by UNDP in 2013 issued a report recommending prescribing future projects to identify WWTPs where anaerobic digestion is conceivable so the scenarios, based on the co-substrates and assess the economics involved in selected options. [14]

6. CONCLUSION

Concluding, the emphasis on Lebanese situation of wastewater should be orientated to management of this sector more than study and implementation.

Lebanese Government through CDR issued tenders and reports concerning the Lebanese stand of wastewater and correlated these tenders with relevant legislation, as the new code of water that has been issued in 2018 to rule this sector according to the international standards and norms.

However, the main issue beside the political and impervious issues, at the technical level, the operation of water facilities and water establishments are strongly recommended to be privatized with convenient setting and strategies that commit to be durably associated to WWTP's energy autonomy exploiting renewable resources & allowable bioenergy feeding in network where applicable.

In this context, Lebanese Ministry of Electrical & Water Resources are restructuring the wastewater sector management through a new vision based on awareness and privatization.

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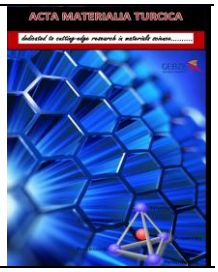

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