Advanced treatment for Domestic Wastewater using INNPT nanoparticles technology in WWTP plants, Egypt

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Abstract—

Shortage of water resources is a big problem facing most countries in the world, therefore, recycling and reuse of wastewater after treatment comes as essential request nowadays.

Also , upgrading existing WWTP to enhance the treated water quality to concede with tertiary treatment as well as to increase plant capacity to treat new flow rate which comes up to at least two to three design capacity of plant , with the condition that there is a shortage in existing plant area

Using a new Innovative Nanoparticles technology "INNPT" allow us to decrease retention time of treatment process to one hour for settling process which allows the capacity increase as well as improve the removal efficiency up to 95 % in existing plants

Pilot plant had been experimented in Fayoum, Cairo, Alexandria, Sharqiah , Helwan and Demiatee over three years

removal efficiency for COD was between 82 % and 99 % while it was between 92 % and 98 % for TSS

Microbiology test showed 100 % removal of fecal coliform (MPN/100 ml) was N.D. as the pilot plant is equipped with UV unit

INNPT nanoparticles material is used to produce treated water comply with new Egyptian Code, FAO regulation and EPA regulation for reuse of treated wastewater in agriculture

Keywords—wastewater, advanced treatment, Nanoparticles, Chemical precipitation, water pasteurization

I. INTRODUCTION

In Egypt volume of wastewater, exceed 4 billion m3/ year, the greatest part of this wastewater treated in 237 WWTP around Egypt.

Biological treatment tech used in more than 95% of those including primary treatment plants, secondary treatment plants

Treatment Efficiency in primary & Secondary Treatment plants removes 70% of COD, BOD and 85% of TSS in wastewater

This efficiency considered not enough for too many reasons as for example:-

1- To save aqua life in water reservoirs "River Nile and lakes "
2- To Reuse Treated waste water in agriculture and industrial Sector [1]

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Therefore, The Demand for new advanced treatment technology become necessary to achieve the following objectives:-

Increase treated water quality for reuse purpose

- Recover of phosphorus & nitrogen from waste water to protect aqua life in Nile River and natural lake which receive treated waste water
- Disinfection of treated waste water from pathogenic bacteria

3- Remove Heavy Metals Traces found in Domestic waste water by precipitating it in insoluble form [2]

In order to achieve those objectives our research and development team worked hard to apply INNPT technology Nanoparticles material to get the following goals as per last objectives:-

- Increase treatment efficiency for removing TSS, COD, BOD up to 99%
- Decrease Retention time to 60 min to get tertiary treatment for domestic wastewater
- Pasteurization of treated wastewater to disinfect pathogenic bacteria

4- Recover of Phosphorus & Nitrogen in Sludge for Reuse [3].

Our applied engineers and chemists worked hard over three years on a pilot plant with 4 cubic meter per hour portable plant to test the new nanoparticles material all over Egypt in about seven governorates, effort bring up the best removal efficiency comply with Egyptian laws for reuse of treated wastewater in agriculture using an economic dose with a little effect in sludge production

This new tech. depends on Nano particles alkaline additives, with a very large surface area and high negative charges, which achieved all objectives and goals of this paper, added new features to existing WWTP, and hope to be able to cover uncovered areas with sewage service within 3 years instead of 12 years as planned

Process Theory

This technology depend on using nanoparticles with a huge surface area as adsorbent, coagulants and precipitators.

INNPT nanomaterial is composed of Aluminum, Ferric and Calcium compounds

The pilot plant process design take place in three steps

- Wastewater suction from plant inlet via 4" hose via a suction pump with 50 m3/h
- Mixing and settling tank with INNPT nanoparticles additives via dosing system for powder and a mixing motor with 400 rpm speed
- Settling takes a 30 min after mixing for 2 min
- Aeration tank to increase DO in treated water
- Pumping system to pump treated water onto a multimedia and activated carbon filters
- UV disinfection system before discharging treated water on final drain

Experimental Methods and materials

- A pilot experiment was applied bet., 22 Jan. 2014 and 16 May 2016. On seven governorates all over Egypt, which taken place in
    - New Cairo (Qatamiah Plant 5000 m^3/d)
    - Fayoum (Qohafah Plant 120000 m^3/d)
    - Alexandria (West Plant 400000 m^3/d
    - Zagazeg (Al Aslogey plant)
    - Cairo (Arab Abo Saad 550000 m^3/d)
    - Domiatee (Zarqaa plant 20000 m^3/d
    -
- In New Cairo , a pilot plant take place for one month , tests had been done by EEAA, NRC labs
    - Removal efficiency.

- After lab experiment, a pilot plant with a capacity of 2.4 m3 for 2 months. The same parameters PH, TSS, BOD, and COD investigated on wastewater before and after treatment.
- After the pilot plant, a commercial case in INTECH WWTP in new Cairo, Cairo. studied in a SBR plant in a Tank with dimension 22*22*6 m for 3 times within 3 months July 2014, August 2014, Sep 2014
- SBR aerator used to mix ECO-NADIC-HMR with wastewater in a volume of 2000 m3
- All lab analysis done in National Research Center, Housing & Building research Center and Balaqs WWTP lab.
    - Tests were applied according to water and wastewater standard spec. part 21 , 2005
    - Treated water with ECO-NADIC-HMR passed through pressured sand filter to adjust TSS,COD and BOD to comply with new Egyptian code for reuse of treated wastewater in agriculture and results shown in table (1)

Results and discussions

- **Raw wastewater**

Table (1)
Balaqas Laboratory experiment results Date: 18/3/2014

Test	Raw waste	Chemical treatment (Dose)					Normal range
		0.5 g	1 g	1.5 g	2 g	2.75 g	
Settling test(ml/l)	1.8	4.5	18	24	28	29	
TSS (mg/l)	215	63	31	24	16	12	50
BOD(mg/l)	190	146	92	67	14		60

This test results a removal efficiency of 94.4% for TSS and 92.6% for BOD
Another test take place on 22/3/2014 on Balaqas plant as in table(2)

Table (2)
Balaqas Laboratory experiment results Date: 22/3/2014

Results showed also a removal efficiency 96% for TSS
With another Laboratory experiment on 23/03/2014 shows a close results to the last two test's results as per table (3)

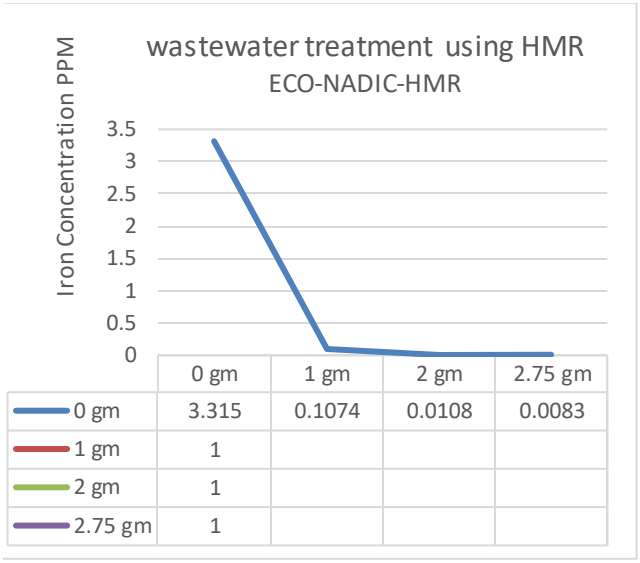
Table (3)
Laboratory experiment on 23/03/2014 on Balaqas plant

Test	Raw waste water	Chemical treatment (Dose)					Normal range
		0.5 g	1 g	1.5 g	2 g	2.75 g	
TSS ppm	200	22	10	8	18	12	50

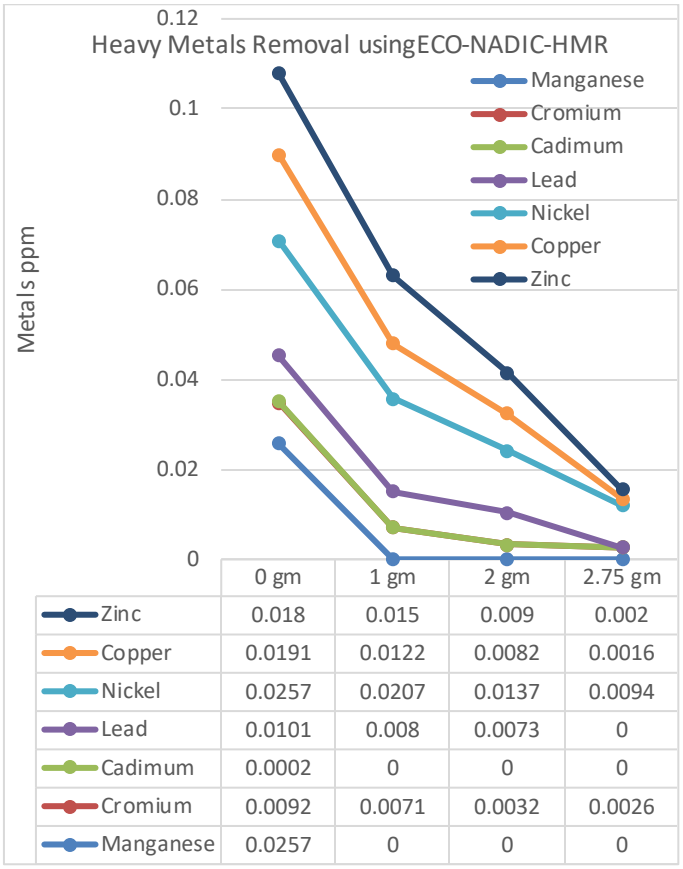
Test	Raw waste water	Chemical treatment (Dose)					Normal range
		0.5 g	1 g	1.5 g	2 g	2.75 g	
TSS ppm	210	71	20	19	4	7	50

Laboratory experiment results shows a removal efficiency of 98% for TSS
After those results, a Laboratory experiment take place in HBRC on 25 /03/2014 for heavy metals removal on six samples with different doses starts from 0.5 g/l, 1.0g/l,1.5 g/l, 2 g/l and 2.75g/l

- Results for Laboratory experiments shows as per Fig(1) , Fig(2) , Fig(3) and Fig(4) that:-.
- 100 % Removal efficiency for Iron, Manganese, Cadmium and Lead and 95% for copper and Zinc
-

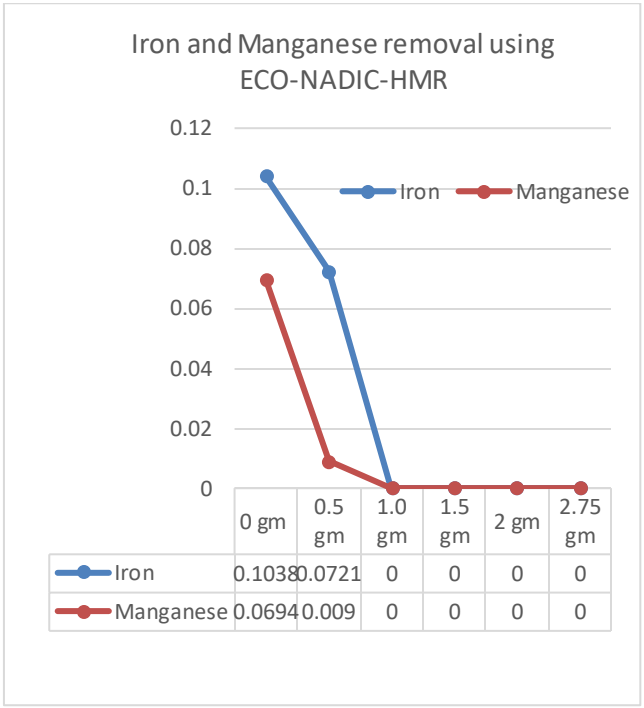


Fig(1) Laboratory experiment results in 9 Feb. 2014 on HBRC



	0 gm	1 gm	2 gm	2.75 gm
Zinc	0.018	0.015	0.009	0.002
Copper	0.0191	0.0122	0.0082	0.0016
Nickel	0.0257	0.0207	0.0137	0.0094
Lead	0.0101	0.008	0.0073	0
Cadimum	0.0002	0	0	0
Cromium	0.0092	0.0071	0.0032	0.0026
Manganese	0.0257	0	0	0

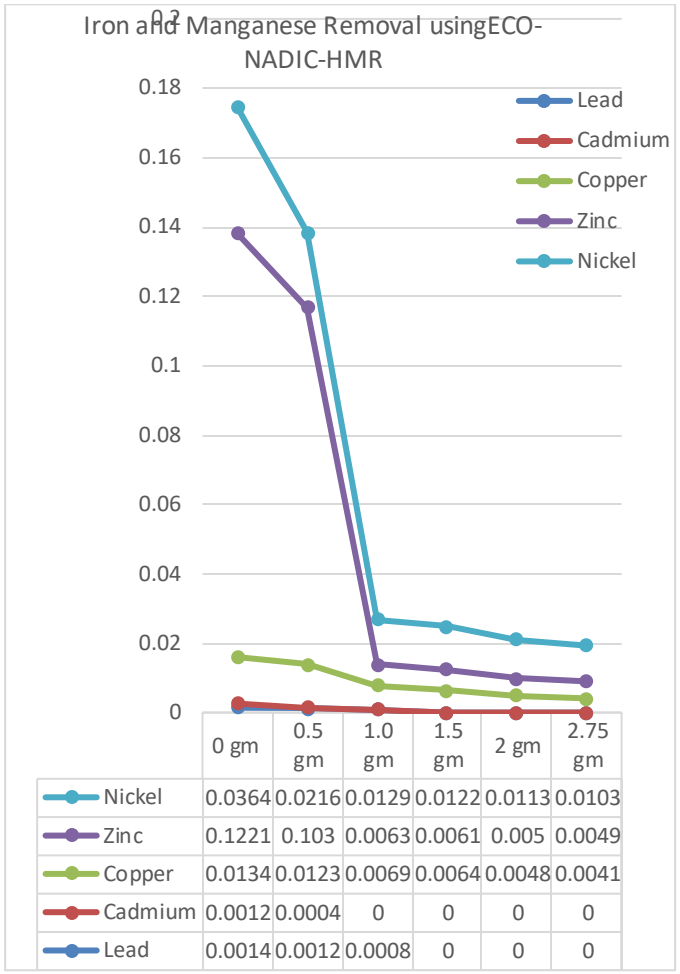
Fig(2) Laboratory experiment results in 9 Feb. 2014 on HBRC



	0 gm	0.5 gm	1.0 gm	1.5 gm	2 gm	2.75 gm
Iron	0.1038	0.0721	0	0	0	0
Manganese	0.0694	0.009	0	0	0	0

Fig(3)

- 100 % Removal of Iron and Manganese make treated water available for a wide range of reuse purposes



	0 gm	0.5 gm	1.0 gm	1.5 gm	2 gm	2.75 gm
Nickel	0.0364	0.0216	0.0129	0.0122	0.0113	0.0103
Zinc	0.1221	0.103	0.0063	0.0061	0.005	0.0049
Copper	0.0134	0.0123	0.0069	0.0064	0.0048	0.0041
Cadmium	0.0012	0.0004	0	0	0	0
Lead	0.0014	0.0012	0.0008	0	0	0

Fig(4) Laboratory experiment results on 25 March 2014 on HBRC

After Laboratory experiments, a pilot in 2.4 m3 tank with mechanical mixer is investigated and test results in Table(4) showed that the removal efficiency of TSS is 98% and 95% for BOD_5 and COD

Table(4)

Lab. Analysis for treated wastewater in pilot Plant

Test	Raw waste	Chemical treatment (Dose)				Normal range
		0.5 g	1 g	1.5 g	2 g	
TSS (mg/l)	350	98	45	18	3.5	50
COD	400	213	140	86	42	80
BOD(mg/l)	234	146	92	36	10	60

After pilot completion, a commercial scale test done in a SBR tank with a volume of 2000 m3. Dimensions of tanks are 22m*22m*6 m height

Commercial scale test take place on INTECH plant , New Cairo , Cairo , Egypt

Test is hold on 27 August 2014

Treated water sent for analysis to NRC and raw water lab analysis done in sewage Authority lab

Table (5)

National Research Center lab analysis results for INTECH tank treated wastewater - in 27 August 2014

Parameter	Raw Wastewater Value	Treated wastewater with HMR value	Eff. %	Value after SF
PH	**7.3**	**7.55**		**7.55**
TSS mg/l	**358**	**18.3**	**94.9**	**8**
COD mg/l	**956**	**76**	**92**	**22**
BOD mg/l	**534**	**30**	**94.3**	**9**
Total Nitrogen	**85**	**26.4**	**69**	**21**
TP	**15**	**0**	**100**	**0**

National Research Center (NRC) results - Table(5) - in 27 August 2014

- Removal efficiency for TSS, COD and BOD are 94.9%, 92% and 94.3% respectively.
- 100 % removal of phosphorus and 69% of Nitrogen

A microbiology lab analysis on treated water on INTECH plant on HBRC as in Table (6) shows that the treated wastewater is comply with Egyptian law and new code for reuse of treated wastewater in irrigation and agriculture

Table (6)

Microbial lab analysis for INTECH tank treated wastewater in HBRC

Test	(Dose) 2 g	Unit	Normal range
Fecal coliform	1.8×10^2	MPN/100 ml	<1000
Salmonella and shigella	Nil	colonies per gram	<1
Nematode	Nil	CFU/100 ml	<1

- When treated wastewater is passed through a pressurized sand filter , water parameters comply with grade A in new Egyptian code for reuse of treated wastewater in agriculture

CONCLUSIONS

- When treated wastewater is passed through a pressurized sand filter , water parameters comply with grade A in new Egyptian code for reuse of treated wastewater in agriculture

In conclusion, the most important reading from investigations in this paper showed the following :-

- Using *ECO NADIC HMR* as a chemical precipitator and coagulant gives good results compared with traditional method in wastewater treatment via using primary , secondary and tertiary treatment plants
- Effect of *ECO NADIC HMR* on removing TSS,COD,BOD is good with efficiency up to 98% when using appropriate mixing system and mixers
- Using *ECO NADIC HMR* eliminates odors produced during wastewater treatment in traditional plants
- Optimum dosage of *ECO NADIC HMR* between 1 g/l to 2 g/l depending on raw wastewater for removal of TSS,COD,BOD
- Optimum dosage of *ECO NADIC HMR* between 1 g/l and 2 g/l depending on raw wastewater for removal of heavy metals
- Using *ECO NADIC HMR* in wastewater improve water quality and kills pathogenic bacteria which saves operation cost and time in plant process as supernatant reefed to plant for re treatment
- Using *ECO NADIC HMR* in wastewater improve water quality by removing 100% of Phosphorus and 69% of nitrogen which save aqua life in reservoirs
- Using *ECO NADIC HMR* not only save a lot of cost and effort for wastewater treatment in traditional operation but also save time and lands required to complete treatment and disinfection process
- *using ECO-NADIC-HMR* comply with EPA constraints and regulation for reuse of treated wastewater in agriculture
- *using ECO-NADIC-HMR* comply with new Egyptian code and FAO constraints and regulation for reuse of treated wastewater in agriculture

- using *ECO-NADIC-HMR* brings Ph value up to 12 which make water pasteurization and destroy most of pathogenic bacteria within the treatment process instead of using disinfection process after treatment in traditional plants
- *ECO NADIC HMR* saves a lot of effort , cost and lands as well as protect public health and saves human lives

Our INNPT Activated Eco-NADIC-HMR Offer the following advantages:-

- Saves initial investment in new WWTP by 60% of traditional plants
- Saves 80% of construction time
- Saves 89% of retention time
- Saves 90% of power consumed
- Saves 85% of workman force
- Saves 80% of Area required
-

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