Innovation for the Best

Plasma Technology for Water and Wastewater Treatment

New Innovative Plasma Cavitation System for Water and Wastewater treatment

Palayesh Plasma Sanat Co.

www.ppsplasma.com

و هر چیز زنده ای را از آب قرار دادیم
شرکت آب و فاضلاب استان آذربایجان شرقی

وَبِرَبِّکُمْ وَتَعَلَّمُونَ
۱۳۲۶
دانشگاه تبریز

P.P.S
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ستاد توسعه فرهنگ علم، فناوری و اقتصاد دانش بنیان
معاونت علمی و فناوری ریاست جمهوری

TPC
شرکت پتروشیمی تبریز
(سهامی عام)

ریاست جمهوری
معاونت علمی و فناوری

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Water and Wastewater

- **Mainly includes hazardous materials for human**
- **The water or liquid carried from waste of industrial processes**
- **This wastewater came from activity of industry, manufacturing, trade or business**

- **Conventional pollutants can include**
  - BOD
  - Total suspended solids
  - pH
  - Fats, oils, grease (FOG)
- **Toxic pollutants include**
  - Heavy metals (arsenic, cadmium, chromium, lead, mercury, etc.)
- **Toxic organics**
  - Voloatile organic compounds (benzene, toluene, methylene chloride, etc.)
  - Semi-voloatile organic compounds (naphthalene, phenols, etc.)
  - Pesticides
  - PCBs

- **Non conventional pollutants**
  - Ammonia
  - phosphates

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challenges facing Water and Wastewater Treatment

Water and wastewater treatment covers the mechanisms and processes used to treat WT and WWT that is produced as a by-product of industrial or commercial activities. After treatment, the treated industrial wastewater (or effluent) may be reused or released to a sanitary sewer or to a surface water in the environment.

Typical WT and WWT is too complicated and costly

Metal	Achievable effluent concentration, mg/l	Technology
Arsenic	0.05	Sulphide precipitation with filtration
	0.06	Carbon adsorption
	0.005	Ferric hydroxide co-precipitation
Barium	0.5	Sulphate precipitation
Cadmium	0.05	Hydroxide precipitation at pH 10-11
	0.05	Co-precipitation with ferric hydroxide
	0.008	Sulphide precipitation
Copper	0.02-0.07	Hydroxide precipitation
	0.01-0.02	Sulphide precipitation
Mercury	0.01-0.02	Sulphide precipitation
	0.001-0.01	Alum co-precipitation
	0.0005-0.005	Ferric hydroxide co-precipitation
	0.001-0.005	Ion exchange
Nickel	0.12	Hydroxide precipitation at pH 10
Selenium	0.05	Sulphide precipitation
Zinc	0.1	Hydroxide precipitation at pH 11

The process for typical methods for petrochemical WWT plants

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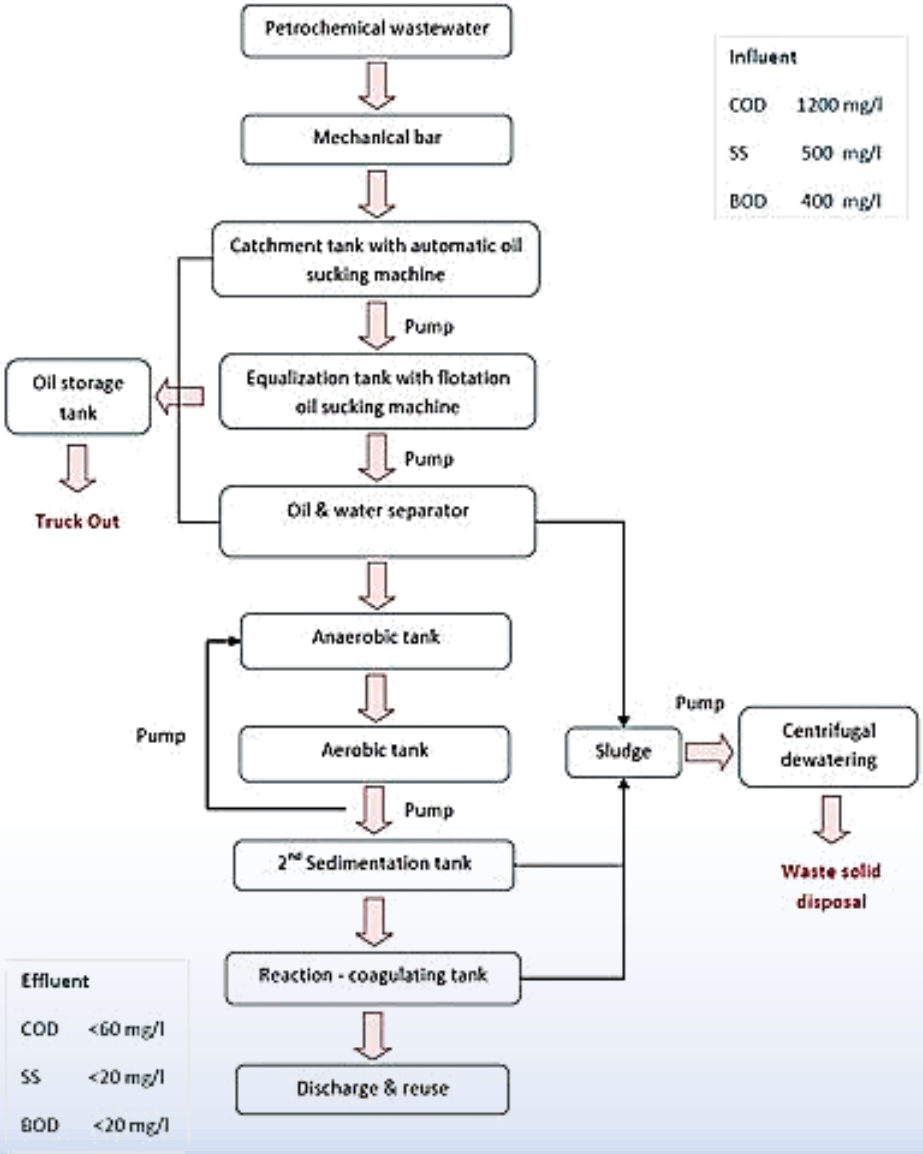
Wastewater treatment in petroleum refineries is a complex process, with demanding environmental management challenges as byproducts can be both volatile and toxic. Petrochemical wastewater often requires a combination of treatment methods to remove oil and other contaminants before discharge.

Issues such as groundwater contamination ; aromatics; oil, grease and organic removal, and VOC control have to be addressed in order to comply with environmental regulations and maintain a good customer image.



Physical method

Chemical methods

Slow Down

pH adjustment

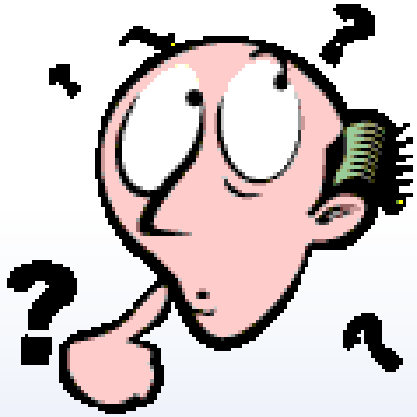
Disinfection

Filtration

Anion exchange

Adsorption

Oxidation



Demineralization

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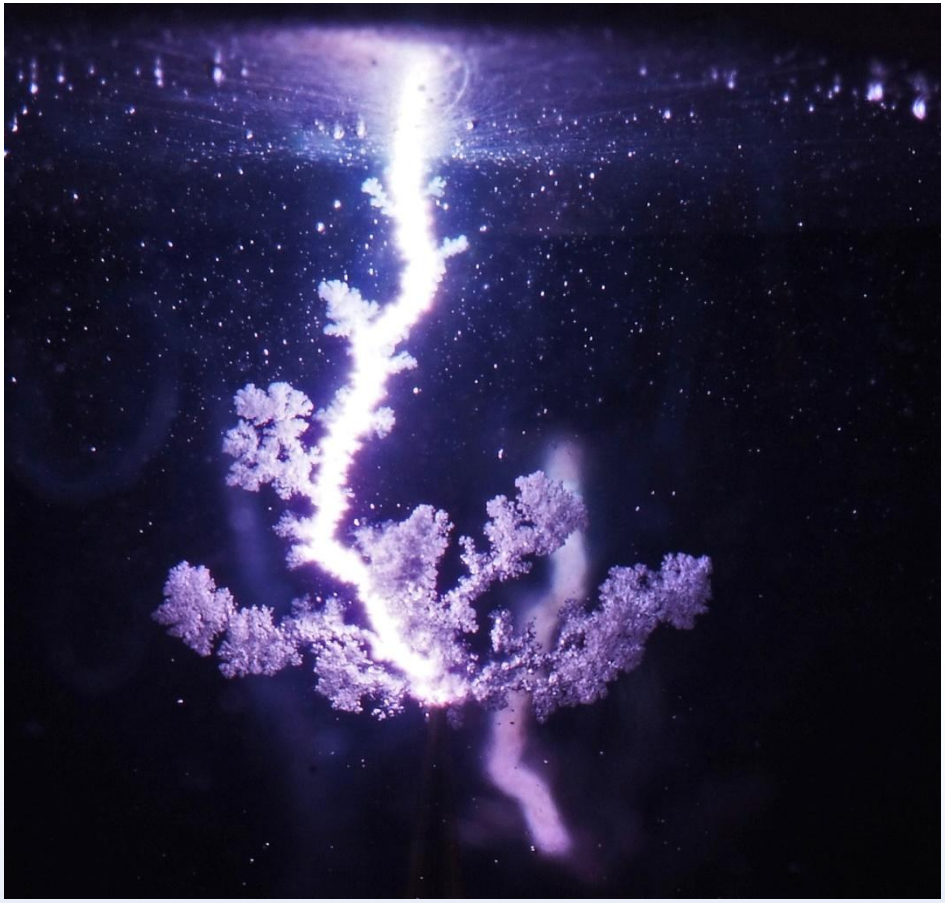
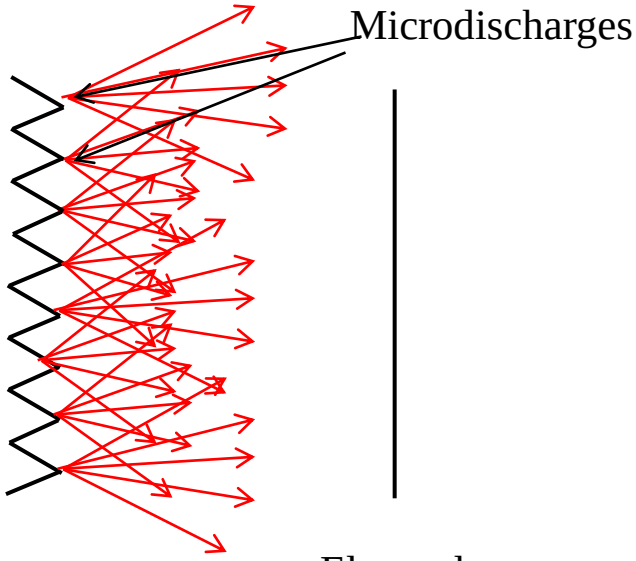
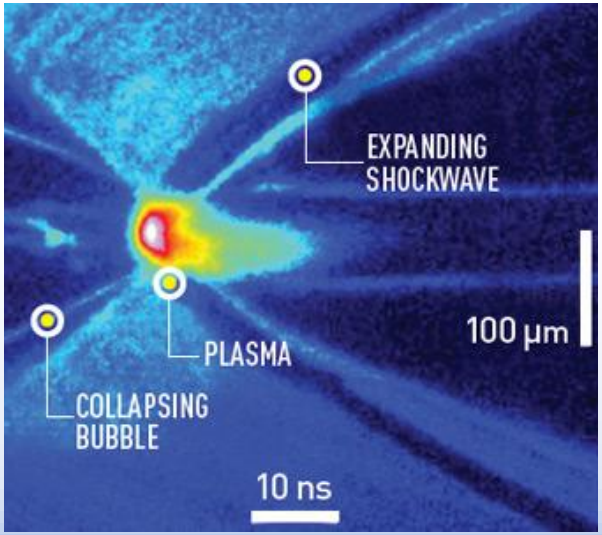
The Plasma Cavitation Method

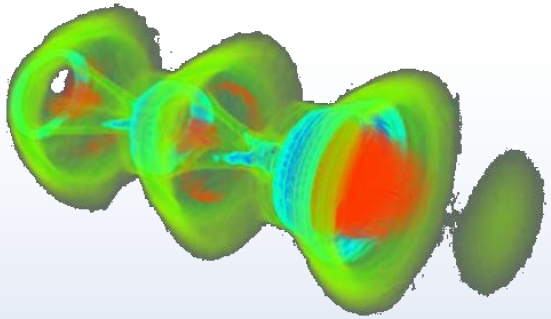


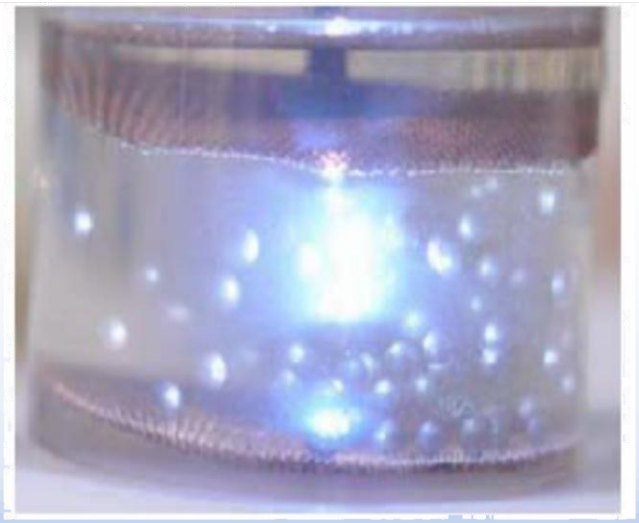
Our work to treatment of these types of Water and wastewaters is based on the plasma cavitations.

Plasma Cavitation System (PCS) is based on completely different procedure to treat the water and industrial wastewater. It is based on combined plasma technology, cavitation technology and nanostructured materials. Because of special design and operation of this system, PCS device only consumes electricity for water and wastewater treatment.


Microdischarges
PPS Nanocoated anode
Electrode


EXPANDING
SHOCKWAVE
PLASMA
COLLAPSING
BUBBLE
100 µm
10 ns





By discharging the current inside water and creation of plasma phase, these chemical reactions typically occurred in the water:

$H_2O + e^- \rightarrow H^+ + OH^-$

$2H_2O + 2e^- \rightarrow H_3O^+ + OH^-$

$H^+ + O_2 \rightarrow HO_2^{3-}$

$OH^- + OH^- \rightarrow H_2O_2 + 2e^-$

$H^+ + H_2O_2 \rightarrow H_2O + OH^-$

$OH^- + H_2O_2 \rightarrow HO_2^{3-} + H_2O$

$OH^- + e^- \rightarrow OH^{2-}$

$H^+ + H_2O \rightarrow H_2 + OH^-$

$H_2O_2 \rightarrow OH^- + OH^-$

$2H_2O + 2e^- \rightarrow H_2 + 2OH^-$

$H_2 \rightarrow 2H^+ + 2e^-$

$OH^- + OH^- \rightarrow H_2 + O_2 + 2e^-$

$O_2 + 2e^- \rightarrow 2O^-$

Plasma causes a number of chemical reactions

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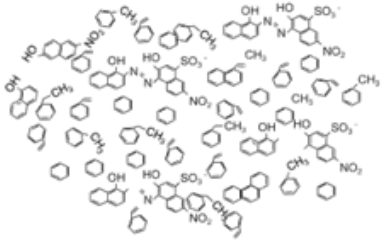
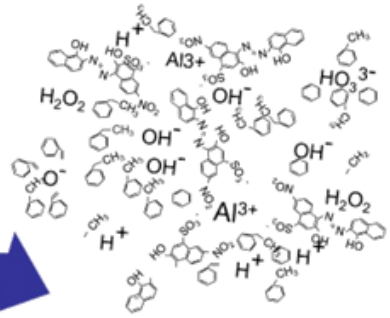
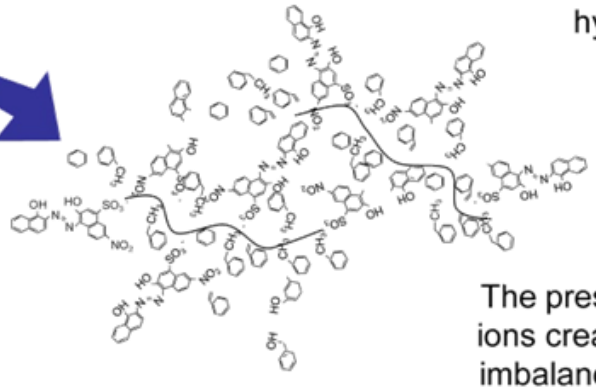
Dissolved VOC and hydrocarbon compounds in OSW

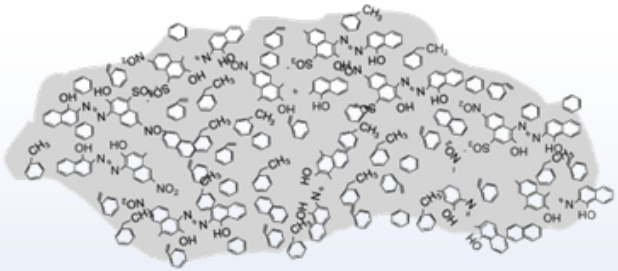




Plasma ions binding of monomeric cationic species to anionic sites of the hydrocarbons molecules, neutralising their charge and resulting in reduced solubility compounds and in some cases, cracking the hydrocarbon molecules.



The presence of the plasma ions create a surface charge imbalance in the suspended particulates and dispersed hydrocarbons and VOC compounds, resulting in flocculation of the particulates or organic materials.



Enmeshment in a precipitate in bottom of plasma reactors

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The Plasma Cavitation Method benefits:

- Only using electricity without any other additives or chemical materials,
- Electricity consumption is about 0.8-2 kwhr/m^3,
- Very low maintenance costs,
- Removing any unpleasant odors,
- Very fast process for treatment (about 2-5 minutes),
- Very simple and user friendly interface,
- Removing and destroying all microorganisms such as bacteria, viruses,
- Removing the heavy metals up to 99/9 % (e.g. Hg, Pb, Cu, Cr(6) etc.),.
- Removing the hydrocarbon (includes alkanes, aromatic, esters, phenols and etc.) by 70%~99%.
- Neutralizing wastewater by bringing pH from 3 or 9 to 6.5-8.5
- Reducing BOD, COD and EC (30%-80%)
- Reducing TDS by 60%-90%.
- Removing dye color by 70%-95%.
- Removing the toxic Volatile Organic Compounds (VOC) emission from aromatic hydrocarbon contained wastewater.
- Installed systems in petrochemical plant have satisfied HSE and oil and gas standards (e.g. API, IEC and AWWA)

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Our Projects and Results

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COD, BOD, Turbidity

Tak Bonab Raisin Company

Parameter	Input to PCS	Output of PCS	Removal rate
BOD5	18308 mg/l	5407 mg/l	**70 %**
COD	25926 mg/l	6086 mg/l	**77 %**
PH	3.66	5.7	**neutralized**
TDS	5176 mg/l	4936 mg/l	**6 %**
EC	7540 µS/cm	7260 µS/cm	**2 %**
TSS	126 mg/l	18 mg/l	**85 %**
Turbidity	783 NTU	7 NTU	**99 %**

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Heavy Metal removal

Tabriz ABFA Organization: Sungun Cooper Mine Company, Pakhir River

DAkkS Deutsche Akkreditierungsstelle D-PL-14401-01-00

فرم گزارش آزمایشگاه آلاینده های کمیاب

(فلزات سنگین فاضلاب)

Test Report Of Heavy Metal Analysis in Waste Water

شرکت آب وفاضلاب آذربایجانشرقی
East Azarbaijan Water & wastewater Co.

Code No : FRLA117 **Revision :04** **Date : 89/09/30**

Delivery Date: تاریخ تحویل نمونه: 94/08/28
Sampler: نمونه بردار: متقاضی
Sampling Place: محل نمونه برداری: نمونه ورودی (سونگون)
Sample code: کد نمونه 940828p91

نمونه برداری توسط متقاضی

روش انجام آزمون Test Method	Maximum Contaminant Level (mg/l) حداکثر مقدار مجاز (mg/l) فاضلاب (سازمان حفاظت محیط زیست) Waste Water (Environmental Protection Organization)			نتیجه RESULT (mg/l)	آزمایش Test
	مصارف کشاورزی و آبیاری	تخلیه به چاه جاذب	تخلیه به آبهای سطحی		
Flame Atomic Absorption 3111-D	5.00	5.00	5.00	-	آلومینیوم (Al)
Flame Atomic Absorption 3111-D	1.00	1.00	5.00	-	باریم (Ba)
Flame Atomic Absorption 3111-B	0.20	0.20	0.20	-	کادمیم (Cd)
Flame Atomic Absorption 3111-B	0.05	1.00	1.00	-	کبالت (Co)
Flame Atomic Absorption 3111-B	2.00	2.00	2.00	-	کروم (Cr)
Flame Atomic Absorption 3111-B	0.20	1.00	1.00	44.11	مس (Cu)
Flame Atomic Absorption 3111-B	3.00	3.00	3.00	-	آهن (Fe)
Flame Atomic Absorption 3111-B	1.00	1.00	1.00	-	منگنز (Mn)
Flame Atomic Absorption 3111-B	2.00	2.00	2.00	-	نیکل (Ni)
Flame Atomic Absorption 3111-B	1.00	1.00	1.00	-	سرب (Pb)
Flame Atomic Absorption 3111-B	2.00	2.00	2.00	-	روی (Zn)
Graphite Tube Atomizer 3113-B	0.10	0.10	0.10	0.014	آرسنیک (As)
Flame Atomic Absorption 3111-D	0.01	0.01	0.01	-	مولیبدن (Mo)

Reference :STANDARD METHODS FOR THE EXAMINATION OF WATER & WASTEWATER

Analysis Cost : هزینه آزمایش:

Remarks ملاحظات

نمونه برداری توسط خود متقاضی انجام شده و نتیجه صرفا جهت اطلاع ایشان صادر و ارزش دیگری ندارد

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۱- مرگونه کپی برداری ازگواهی فوق ممنوع است
۲- این گواهی بدون مهرآزمایشگاه فاقد اعتبار است

DIN EN ISO/IEC 17025 : 2005
ISO 9001 : 2000
OHSAS 18001 : 1999
ISO 14001 : 2004
آزمایشگاه مرجع

Quality Control Manager: مدیر کنترل کیفی **Lab. Expert:** کارشناس آزمایشگاه

DAkkS Deutsche Akkreditierungsstelle D-PL-14401-01-00

فرم گزارش آزمایشگاه آلاینده های کمیاب

(فلزات سنگین فاضلاب)

Test Report Of Heavy Metal Analysis in Waste Water

شرکت آب وفاضلاب آذربایجانشرقی
East Azarbaijan Water & wastewater Co.

Code No : FRLA117 Revision :04 Date : 89/09/30

Delivery Date: تاریخ تحویل نمونه: 94/08/28
Sampler: نمونه بردار: متقاضی
Sampling Place: محل نمونه برداری: نمونه خروجی (سونگون)
Sample code: کد نمونه 940828p92

نمونه برداری توسط متقاضی

روش انجام آزمون Test Method	Maximum Contaminant Level (mg/l) حداکثر مقدار مجاز (mg/l) فاضلاب (سازمان حفاظت محیط زیست) Waste Water (Environmental Protection Organization)			نتیجه RESULT (mg/l)	آزمایش Test
	مصارف کشاورزی و آبیاری	تخلیه به چاه جاذب	تخلیه به آبهای سطحی		
Flame Atomic Absorption 3111-D	5.00	5.00	5.00	-	آلومینیوم (Al)
Flame Atomic Absorption 3111-D	1.00	1.00	5.00	-	باریم (Ba)
Flame Atomic Absorption 3111-B	0.20	0.20	0.20	-	کادمیم (Cd)
Flame Atomic Absorption 3111-B	0.05	1.00	1.00	-	کبالت (Co)
Flame Atomic Absorption 3111-B	2.00	2.00	2.00	-	کروم (Cr)
Flame Atomic Absorption 3111-B	0.20	1.00	1.00	2.09	مس (Cu)
Flame Atomic Absorption 3111-B	3.00	3.00	3.00	-	آهن (Fe)
Flame Atomic Absorption 3111-B	1.00	1.00	1.00	-	منگنز (Mn)
Flame Atomic Absorption 3111-B	2.00	2.00	2.00	-	نیکل (Ni)
Flame Atomic Absorption 3111-B	1.00	1.00	1.00	-	سرب (Pb)
Flame Atomic Absorption 3111-B	2.00	2.00	2.00	-	روی (Zn)
Graphite Tube Atomizer 3113-B	0.10	0.10	0.10	0.012	آرسنیک (As)
Flame Atomic Absorption 3111-D	0.01	0.01	0.01	-	مولیبدن (Mo)

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Analysis Cost : هزینه آزمایش:

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نمونه برداری توسط خود متقاضی انجام شده و نتیجه صرفا جهت اطلاع ایشان صادر و ارزش دیگری ندارد

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آزمایشگاه مرجع

Quality Control Manager: مدیر کنترل کیفی Lab. Expert: کارشناس آزمایشگاه

Cu ion removal rate is up to 96 %

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Heavy Metal removal

Tabriz Industrial Zone for Leather Production (Charmshahr of Tabriz)

Parameter	Input to PCS	Output of PCS	Removal Rate
BOD_5	780 mg/l	130 mg/l	**83 %**
COD	1630 mg/l	228 mg/l	**86 %**
pH	4.8	7.83	**-**
EC	22700 µS/cm	10010 µS/cm	**60 %**
DO	1.7 mg/l	4 mg/l	**-**
Turbidity	149 NTU	9 NTU	**94 %**
Total Coli form	1100 mpn/100ml	150 mpn/100ml	**86 %**
Fecal Coli form	1100 mpn/100ml	40 mpn/100ml	**96 %**
Cr (+6)	700 mg/l	0.05 mg/l	**99.9 %**

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Heavy Metal removal

Input to PCS

output from PCS

Mineral drinking water

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VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

Phase 1: Installation of first device of cluster for large scale treatment

In “Phase 1” level, we designed and manufactured an industrial scale of our pilot device. The dices fabricated in January 2016 and installed in TPC in February 2016. The photos of our PCS device with the 20 m^3/hour or 480 m^3/day

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VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

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VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

results of 100m^3/day PCS device in TPC

	Compound name	Input (ppm)	Output (ppm)	Removal rate
1	Benzene	8.3	3	**64%**
2	Toluene	8	2	**75%**
3	Ethylbenzene	51	6	**88%**
4	Styrene	171	28	**84%**
5	Total	238.3	39	**84%**
6	COD	835	275	**77%**

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VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

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VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

results for 20 m^3/hr PCS device in TPC on 12th March 2016.

	Compound name	Input (ppm)	Output (ppm)	Removal rate
1	Benzene	4.6	2.1	**54 %**
2	Toluene	5	1.4	**72 %**
3	Ethylbenzene	5.2	0.79	**85 %**
4	Styrene	33	5.7	**83 %**
5	Total	47.8	9.99	**79 %**

results for 20 m^3/hr PCS device in TPC on 2nd May 2016.

	Compound name	Input (ppm)	Output (ppm)	Removal rate
1	Benzene	4.9	1.8	**63 %**
2	Toluene	5.4	1.3	**76 %**
3	Ethylbenzene	5.5	0.7	**87 %**
4	Styrene	35.6	5.8	**84 %**
5	Total	51.4	9.6	**81 %**

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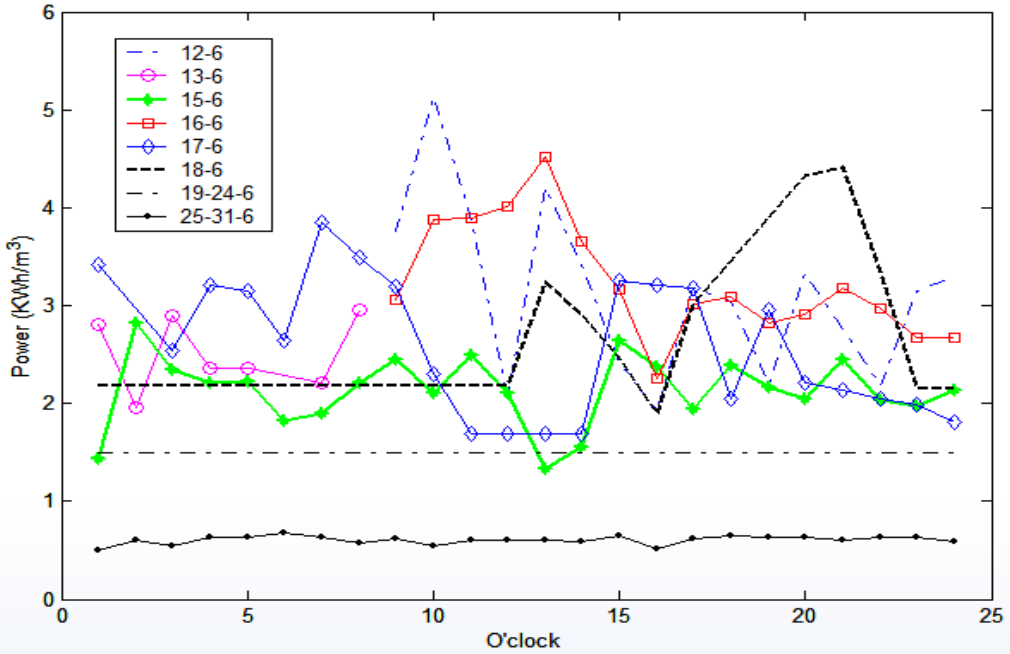
VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

Energy consumption Analysis



Recorded One-month electricity consumption by 1m^3/hr device

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Large scale VOC and Hazardous Hydrocarbon Removal

Tabriz Petrochemical Plant WWT Project

Finishing the project:
March 2018

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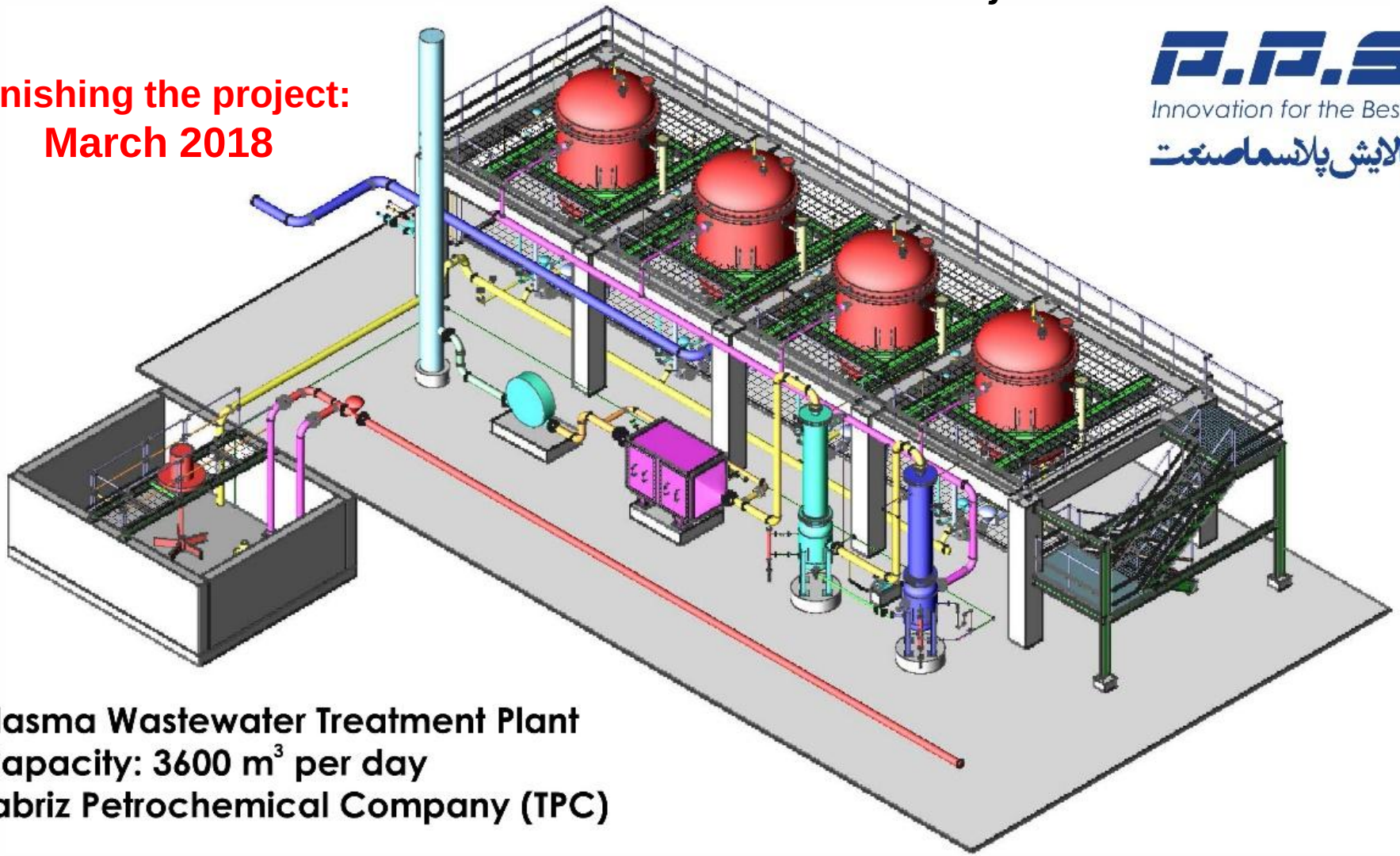
پالایش پلاسما صنعت



Plasma Wastewater Treatment Plant
Capacity: 3600 m^3 per day
Tabriz Petrochemical Company (TPC)

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Heavy metal removal from drinking water

Tabriz ABFA Organization

شـــرکت آب و فـــاضلاب استان آذربایجان شرقی

Phase 1: pilot plant for 100 m^3/day.

As removal efficiency rate is up to 99.9 %

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Large scale Heavy metal removal from drinking water

Tabriz ABFA Organization

Phase 2:

Heavy metal removal from drinking water, East Azerbaijan 1000 m3/day

After successfully operation of pilot device for heavy metal removal, a large scale plasma device ordered by Tabriz ABFA organization for heavy metal removal. This project will be completed by the end of October 2017.

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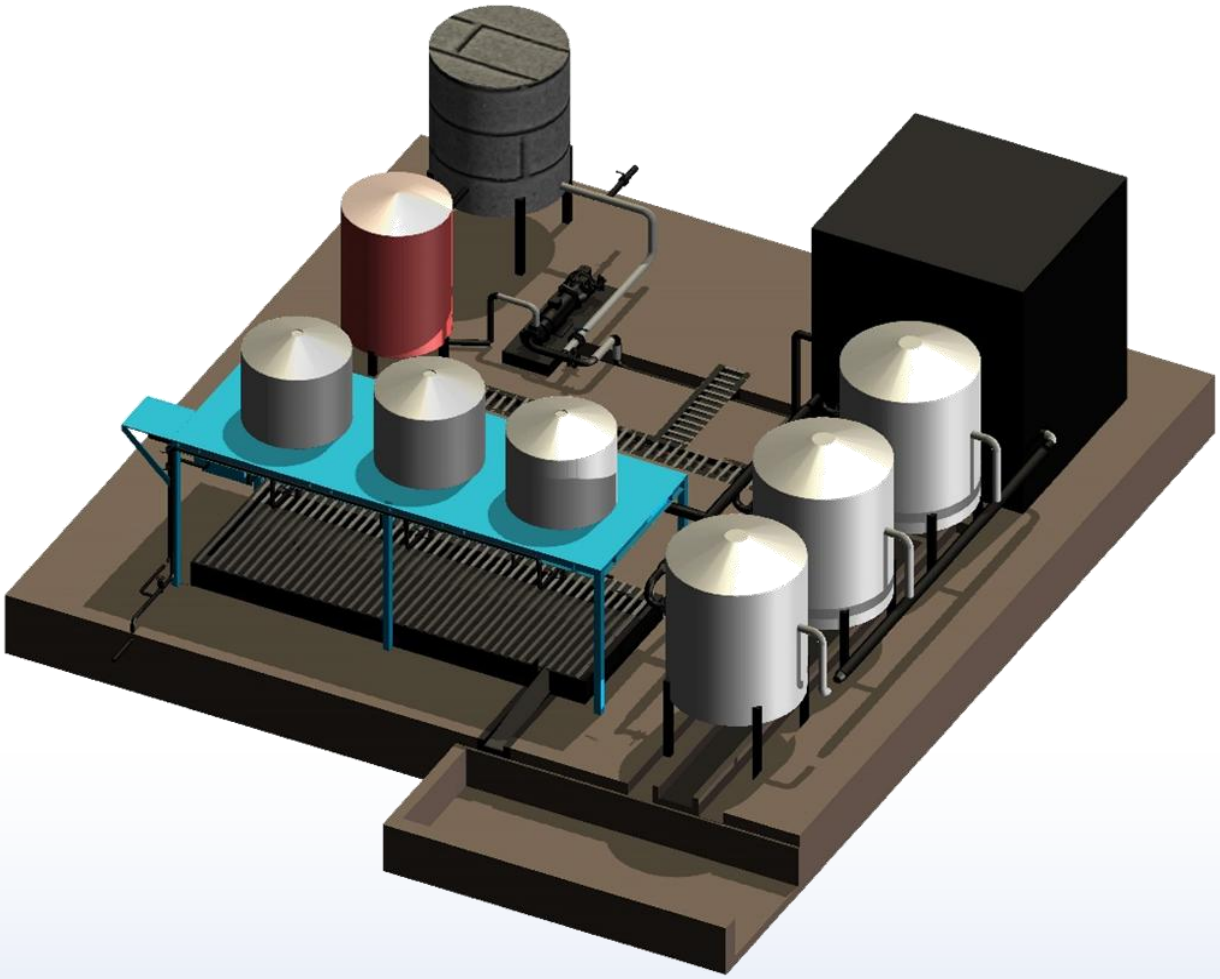

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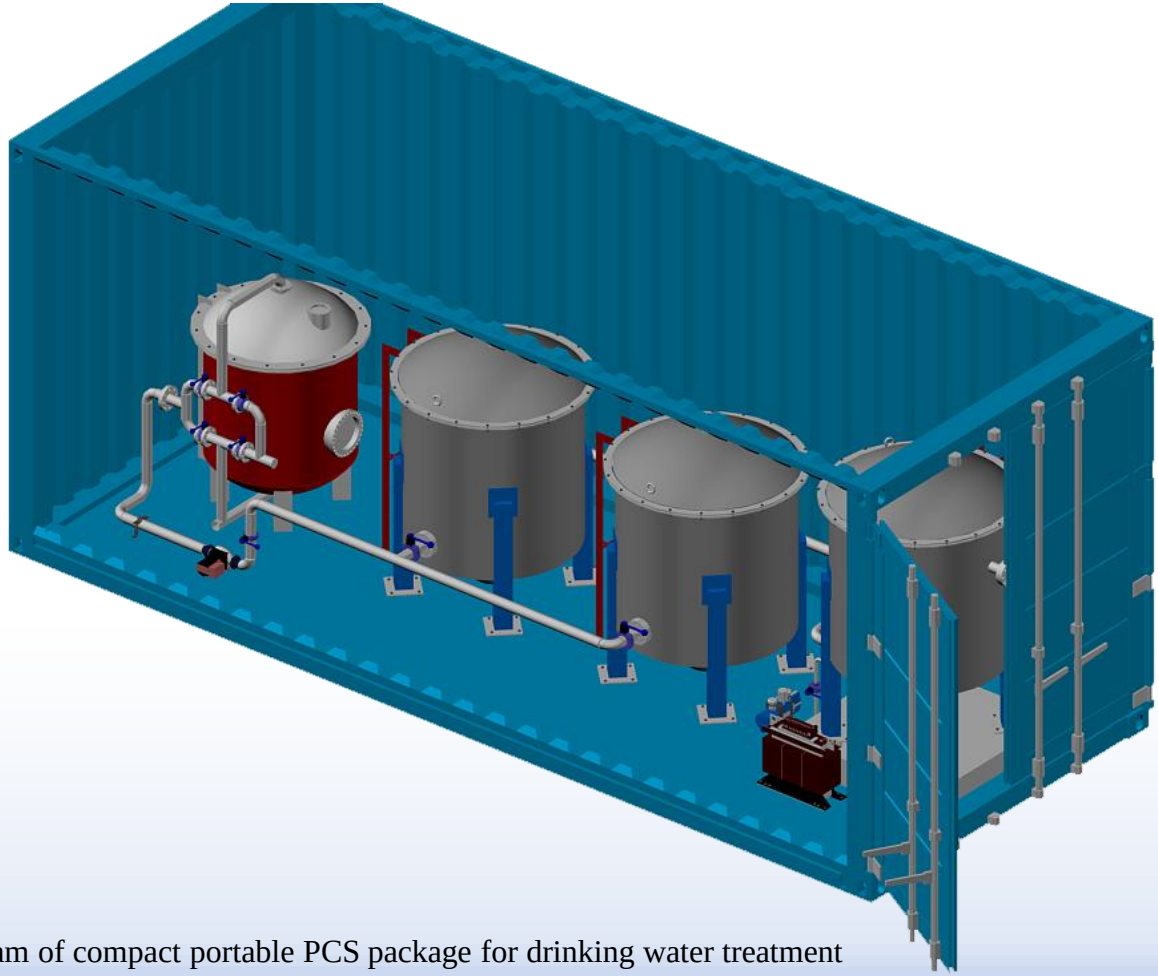
In addition, our company designed compact portable package for pits with the capacity of 10 to 200 m^3/day and first device will be installed in low population areas such as tourism sites and villages.



Schematic diagram of compact portable PCS package for drinking water treatment

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The Plasma Cavitation Cost Analysis

After successfully lunching the pilot device with **20 m3/day**, we started to large – scale system with **20 m^3/hr.**

Parallel using of this system, may be implemented for large scale application.

Based on **8** months continuously working in three different seasons (winter, spring and summer) it found that our system only consumes **0.8- 2 kWh per 1 m^3 wastewater**.

Maximum system cost for 1 m^3 wastewater is about **15 cents**, which is very compatible with price in comparison to conventional methods that the cost is about 0.5 to 1.5 €.

Designing and manufacturing costs are related to the type of the wastewater, but the cost of device with power supply, main reactor and valves is about **40/000 €** per **20 m^3/hr**.

Innovation for the Best

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Many Thanks for Your Attention!