Strategies for Improving Pharmaceutical Wastewater Treatment Processes

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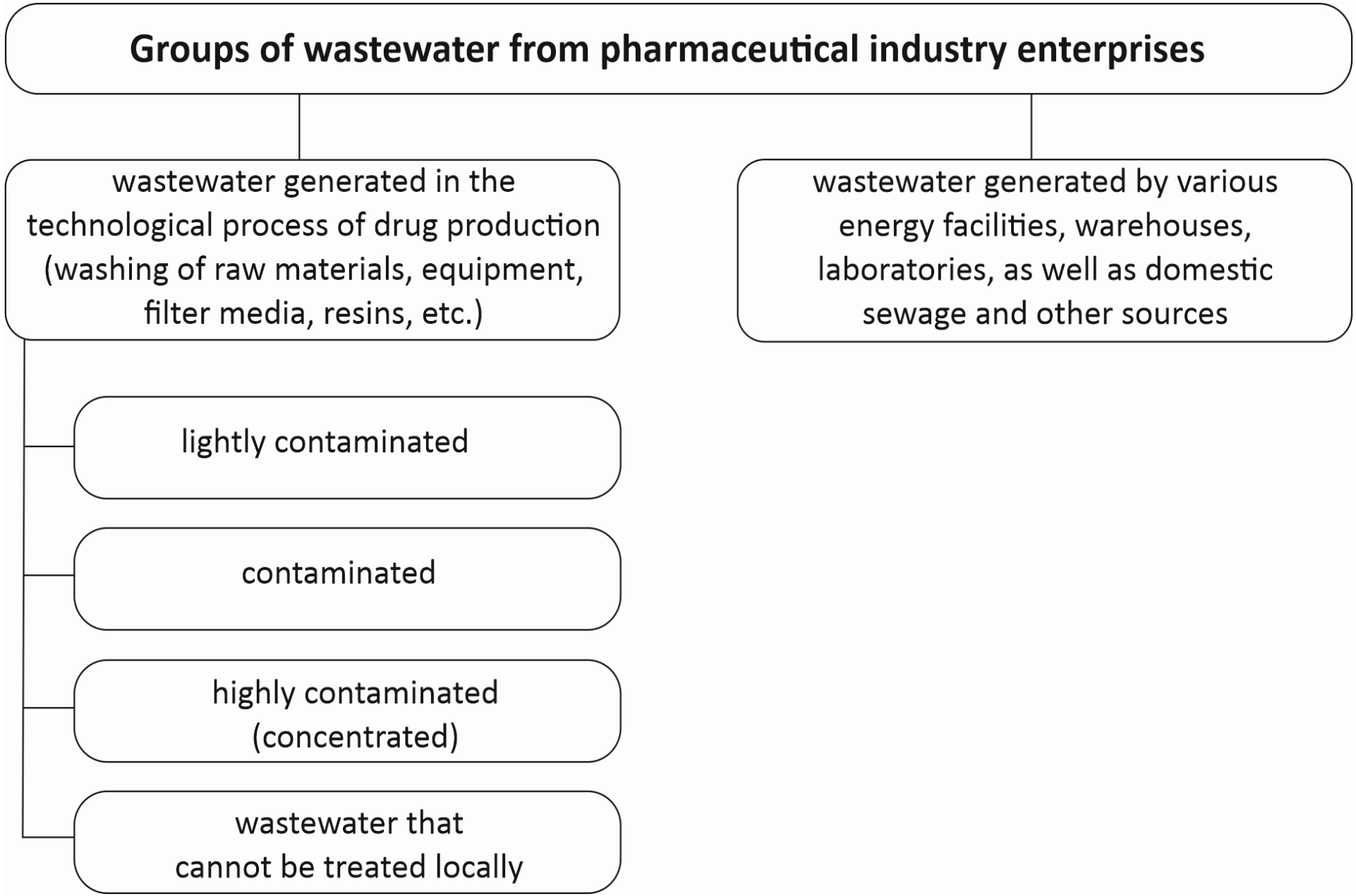
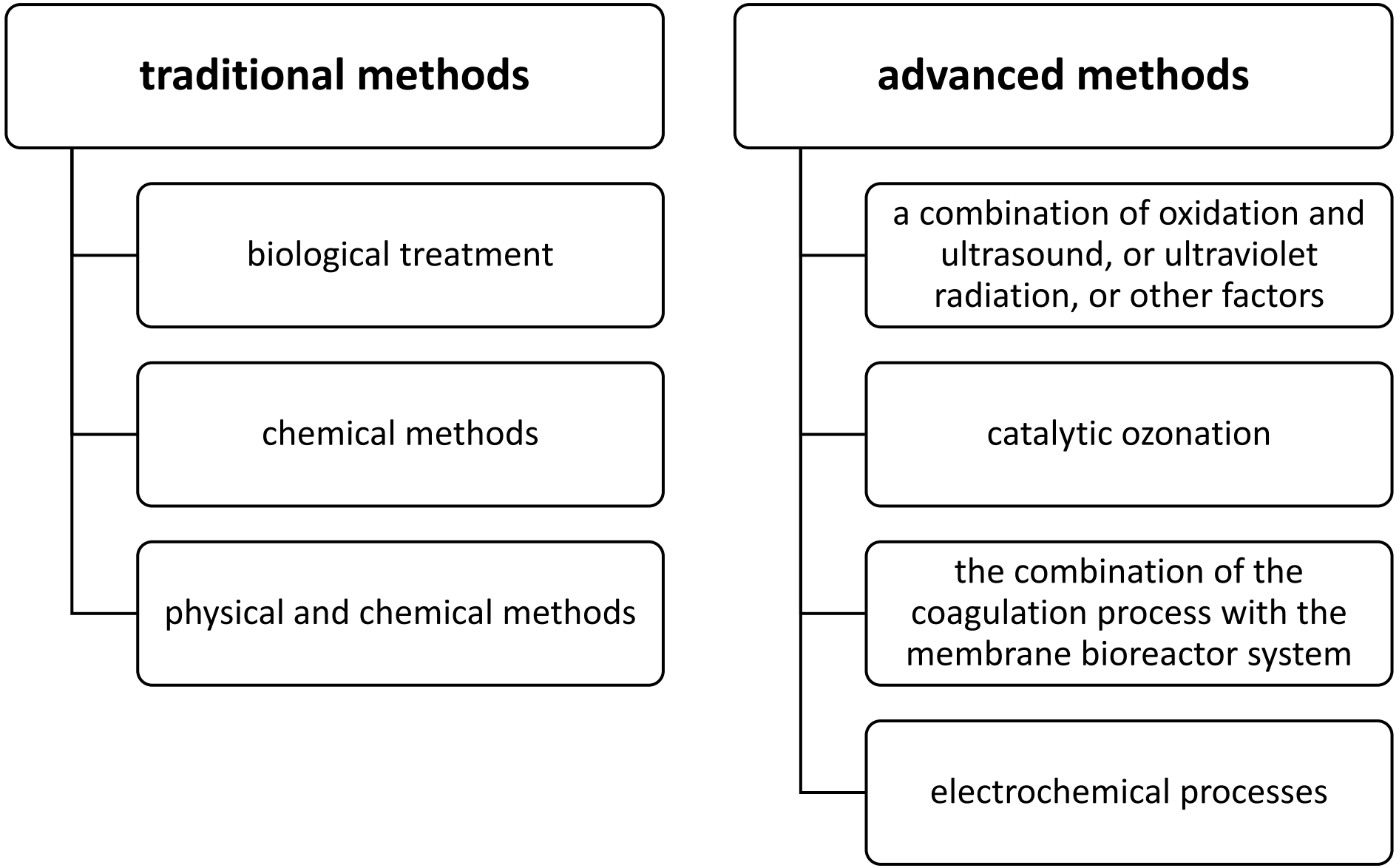

Groups of wastewater from pharmaceutical industry enterprises
wastewater generated in the technological process of drug production (washing of raw materials, equipment, filter media, resins, etc.)
wastewater generated by various energy facilities, warehouses, laboratories, as well as domestic sewage and other sources
lightly contaminated
contaminated
highly contaminated (concentrated)
wastewater that cannot be treated locally

Technologies for the treatment of wastewater containing pharmaceutical compounds



The Fenton oxidation process

Advanced oxidation processes are based on oxidative destruction reactions initiated by the action of several substances or factors.

One of the reagents used at the physicochemical stage of wastewater treatment is the Fenton reagent. This method is based on the reaction of hydrogen peroxide (H_2O_2) with iron (Fe^{2+}), which leads to the formation of hydroxyl radicals (OH·, OOH·).

The formed radicals are powerful oxidizing agents that can degrade organic pollutants, including complex pharmaceutical compounds.

The oxidation process is a chain reaction in which the formation of OH· marks the beginning of the chain, while other reactive oxygen species and intermediate reaction products form the nodes of the chain. As these reactive oxygen species are consumed, the reaction chain is terminated.

The mechanism of the reaction is relatively complex - these reactive oxygen species attack organic molecules and mineralize them into inorganic substances, such as CO_2 and H_2O.

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH\cdot + OH^-,$$

$$Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + OOH\cdot + H^+$$

influencing factors

- ✓ temperature
- ✓ pH
- ✓ qualitative and quantitative content of organic compounds in the water
- ✓ dosage of hydrogen peroxide and catalyst

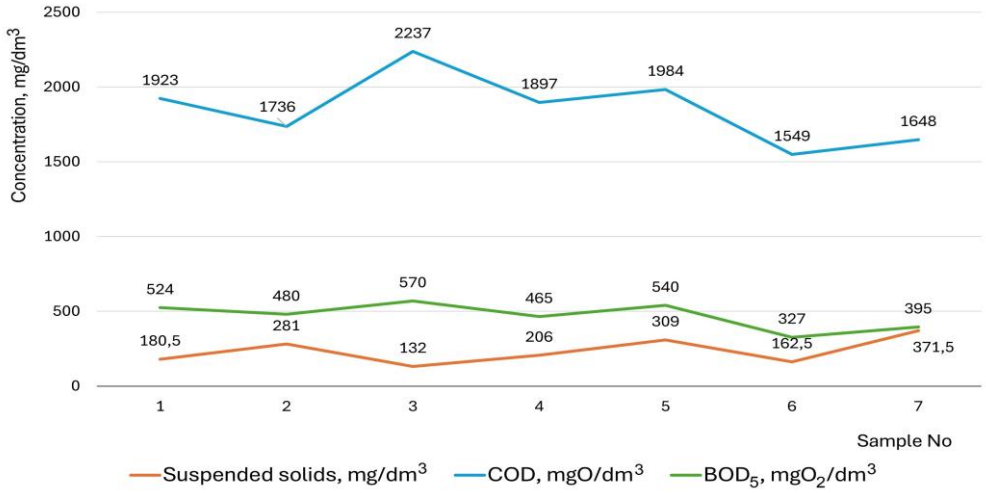
Methods of the pharmaceutical enterprise wastewater treatment

- **mechanical** - removal of solid impurities larger than 0.7 mm by straining through a drum sieve
- **chemical** - based on the use of an oxidizing agent and a coagulant
- **biological** - involves the treatment of wastewater in a biological reactor (aeration tank) filled with activated sludge
- treatment on a closed (hermetic) **bioplateau**, where excess heavy metals are removed from wastewater during the flow through the biomass of the roots of energy plants planted there
- **disinfection** - adding a disinfectant and benzoic acid, dissolved and diluted to a certain concentration

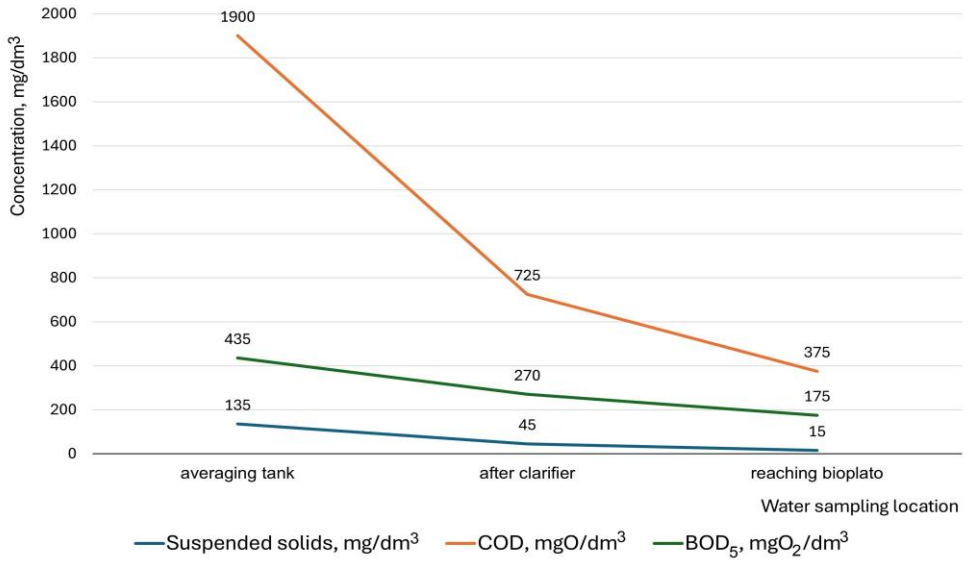
Concentrations of contaminants in pharmaceutical wastewater

Indicators	The average value
pH, un.	7.67
Suspended solids, mg/dm^3	234.6
Dry residue, mg/dm^3	1365
Ammonium nitrogen, mg/dm^3	40.83
Ammonium ions, mg/dm^3	52.28
Nitrite ions, mg/dm^3	0.17
Nitrate ions, mg/dm^3	2.07
Phosphate ions, mg/dm^3	11.48
Anionic surfactants, mg/dm^3	4.44
COD, mgO/dm^3	1850
BOD_5, mgO_2/dm^3	471

Indicators of suspended solids, COD and BOD_5 in the wastewater of the pharmaceutical enterprise



Dynamics of reduction of suspended solids, COD and BOD_5 in the wastewater of the pharmaceutical enterprise after the start of the LWTP* operation



*LWTP - local wastewater treatment plant

Concentrations of contaminants in the wastewater of the pharmaceutical enterprise after the implementation of the use of Fenton's reagent in the technological scheme

Indicators	Water sample from averaging tank	Water sample from primary clarifier	Water sample from process water tank
pH, un.	7.38	7.13	7.4
Ammonium nitrogen, mg/dm^3	37.07	39.45	0.35
Nitrites, mg/dm^3	0.05	-	0.42
Nitrates, mg/dm^3	0.28	-	166.0
Orthophosphates, mg/dm^3	9.25	3.05	2.95
Anionic surfactants, mg/dm^3	5.17	-	0.12
Petroleum products, mg/dm^3	0.4	-	≤ 0.005
COD, mgO/dm^3	1732.0	377	58.1
Dry residue, mg/dm^3	1258.0	-	1146.0
Iron total, mg/dm^3	1.0	≤ 10.0	0.25

Data of microbiological research of activated sludge composition in the LWTP aeration tank

Types of microorganisms	Amount
Amoebae: Centropyxis aculeate	1
Arcella vulgaris	3
Arcella discoides	1
Infusoria: Vorticella microstoma	16 (closed peristomes)
Aspidisca costata	1
Rotisseries: Rotaria rotatoria	2 (immobile)
Bacteria: Zoogloea ramigera	little
Filamentous bacteria	Type 021N (little)
Total number of species:	7

Data of microbiological research of activated sludge composition in the LWTP aeration tank after the implementation of Fenton's reagent in the technological scheme

Types of microorganisms	Amount
Amoebae: Amoeba proteus	221
Infusoria: VLitonotus lamella	11
Epistylis bimarginata	55
Vorticella microstoma	21
Vorticella convallaria	266
Vorticella nutans	52
Stentor roelesi	4
Aspidisca costata	7
Paracineta tuba	17
Staurophrya elegans	12
Rotisseries: Philodina roseola	9
Rotaria rotatoria	13
Cephalodella incila	6
Lecane inermis	27
Other predators: Ticks	4
Monhistera sp	2
Bacteria: Spirillae	present
Zoogloea ramigera	-
Filamentous bacteria	Microthrix parvicella, Type 1701, Type 021N, Nostocoida limicola
Total number of species:	21

Conclusions

When summarizing the results of observations and analyzing the data of studies of water treatment indicators, the following conditions for the implementation of the technological process were determined:

- ✓ introduction of a catalyst – to initiate the reaction, ferrous iron (Fe^{2+}) is injected before the clarifier, which serves as a catalyst. This iron activates hydrogen peroxide (H_2O_2), which leads to the formation of hydroxyl radicals (OH·, OOH·) that can destroy organic pollutants;
- ✓ addition of an oxidizing agent - hydrogen peroxide is injected into the clarifier, where the reaction between H_2O_2 and Fe^{2+} leads to intensive oxidation of organic compounds;
- ✓ as a result of the experiments, the optimal concentration of reagent solutions was determined - 5 % concentration of both components;
- ✓ the dosage of ferrous sulfate is 0.6 l/h, and hydrogen peroxide - 0.2 l/h, i.e. in the ratio 3:1.

THANK YOU VERY MUCH
FOR YOUR ATTENTION!