# THE IMPACT OF TEXTILE WASTEWATER ON NUTRIENTS REMOVAL

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**ABSTRACT**
The article focuses on the impact of textile effluents contaminations on phosphorus and nitrogen removal in joint biological treatment process of municipal sewage and industrial wastewater. The cotton mill effluents contain nonbiodegradable or difficulty biodegradable products, like: dyes, surfactants, special finish preparates and high salts concentrations. The BOD to COD ratio of the wastewater is between 0.15 to 0.48. Daily organic substances load of textile wastewater varies between 20 to 40 % of total organic load at the municipal treatment plant. The increase of COD load introduced with textile effluents has caused a decrease in achieved results of phosphorus removal. The results of nitrifications are in correlation with the percentage contribution COD load carried by textile effluents to COD of municipal sewage. With the increase of textile mill effluents COD, to municipal sewage COD ratio a decrease of nitrification results were observed.

**KEYWARDS**
Cotton mill effluents; nitrification; phosphorus removal; textile wastewater treatment

## INTRODUCTION

Most often textile wastewaters after preliminary treatment are discharged to municipal sewage treatment plants for joint biological treatment, (Anielak, 1995; Dałek et al. 1999). Doing so, there is a good chance to achieve high effects of organic substances, including dyes removal, from the textile mill effluents. If textile mills effluents, constitutes only a small quantity in comparison to municipal sewage it is assumed that they will not impose an adverse effect on the biological treatment processes. Almost no attention is given to the impact of organic compounds in textile mills effluents on nutrients removal. With the more stringent requirements on nutrients concentration in the treated effluents it was found necessary to get a better insight on the impact of textile wastewaters on nutrients removal on combined municipal sewage treatment process.
The paper describes a case study where cotton mill effluents are discharged to a municipal treatment plant.

## METHODOLOGY

The cotton mill is discharging large amounts of highly contaminated wastewaters. This is because finish textile processes like: bleaching, mercerization, dyeing, printing and refining processes are using nonbiodegradable or difficulty biodegradable products as well as eventually toxic substance, like dyes, surfactants, special finish preparates, (Krauze et al. 1995). Also other compounds used in

the production processes of textile articles can be difficult to be removed in biological processes and they can hinder the municipal sewage treatment process.
The textile mill wastewaters are pretreated at the factory. The raw textile wastewaters have high pH (11-12) values, salts and dyes concentrations. They are neutralized with gaseous carbon dioxide to a pH of 7.5 – 7.8 applying a Solvocarb – B process. The consecutive step is equalization of flow and quality (contaminants concentrations). Next the wastewaters are pumped to a retention tank at the treatment plant Andrychow, mixed with municipal sewage and treated in biological process. The textile wastewaters from the cotton mill are characterized by high COD concentrations in the range from 300 to 2000 $mgO_2/dm^3$ and occasionally have even higher concentrations, (Mrowiec, 2003). Compounds contained in textile wastewater are difficulty biodegradable, because the BOD to COD ratio of the wastewater is between 0.15 to 0.48, (Miksch, 2000). The textile wastewaters flow varies in the range from about 1000 up to 1800 $m^3/d$.

Municipal sewage is transported to the treatment plant by a mixture of combined and separate sewerage system. The average daily flow of municipal sewage is about 20 000 $m^3/d$. Raw sewage is flowing through screens, and an aerated grit chamber. After the preliminary processes sewage is flowing by open channels to a distribution tank in front to primary settling tanks. The retention time in the primary settling tanks is about 4.2 hours. Municipal sewage after the mechanical treatment is discharged to a storage – equalization tank, to which also the textile mill effluents are supplied. From that basin, the mixture of municipal and textile wastewaters are discharged to the activated sludge process. For aeration, surface aerators are used. The hydraulic retention time in the activated sludge chambers is approximately 5.8 hours. There is a very low activated sludge recirculation rate applied in the order of 36 %. Two secondary settling tanks have a hydraulic retention time of about 7.6 hours. Treated wastewater is discharged to the Wieprzowka River. Sludge from the primary and secondary settling tanks after thickening is digested anaerobically in closed and heated tanks. The digested sludge is dewatered on drying beds or by using centrifuges. Produced biogas is utilized for heating. The technological scheme of the wastewater treatment process at the treatment plant Andrychow is presented in Fig. 1. For example, the characteristic to the investigated case, quality of textile, municipal and treated wastewater is presented in table 1.

Wastewater treatment plant Andrychow.
**1** - screens and blowers station, **2 –** grit chamber, **3 –** grit container, **4 –** sewage screenings container, **5 –** overflows, **6 –** primary settling tanks, **7 –** sewage pumping station, **8 –** activated sludge chambers, **9 –** surplus and recirculated sludge pumping station, **10 –** secondary settling tanks, **11 –** sludge thickeners, **12 –** pumping station and wastewater tank (old wastewater treatment plant), **13 –** sludge pumping station, **14 –** power machine building**, 15 –** closed digesters, **16 –** installation shaft, **17 -** storage – equalization tank, **18 –** drying beds, **19 –** mechanical dewatering station – centrifuges, **20 –** dry sludge disposal site**, 21 –** biogas tank, **22 –** administrative building, **23 –** garages, **24** – boiler house, **25 –** laboratories, **26 –** repair shop, **27 –** textile wastewater tanks - equalization tanks, **28 –** textile wastewater pumping station, **29 –** textile wastewater settling tanks**, 30 –** store room.

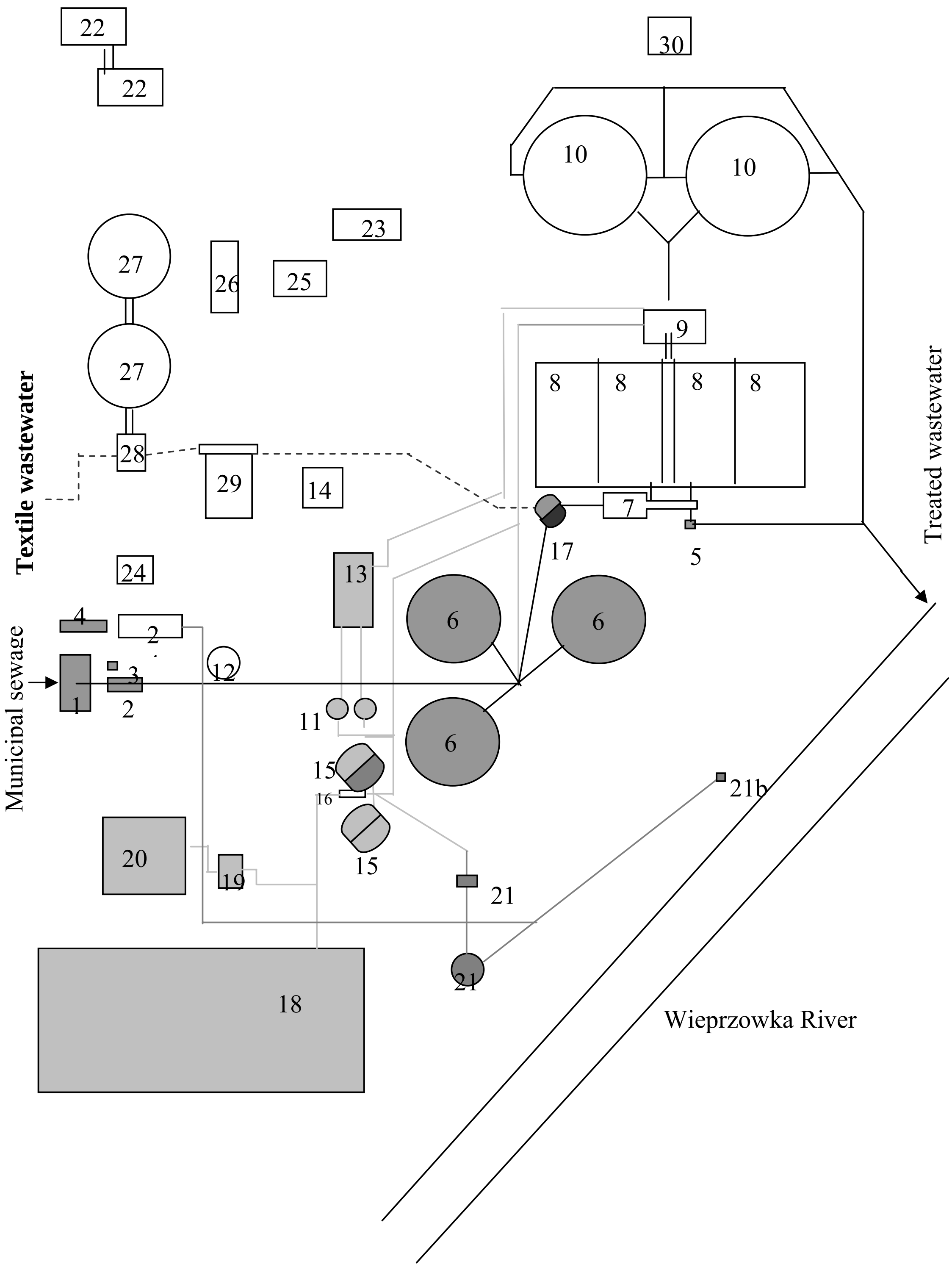


**Figure 1**. The technological scheme of the Andrychow wastewater treatment plant.

**Table 1**. Investigated wastewaters quality.

| No | Parameters | | Unit | Wastewaters | | |
|---|---|---|---|---|---|---|
| | | | | **textile** | **municipal** | **treated** |
| 1. | Colour | | mgPt/dm$^3$ | blue | 60 | 30 |
| 2. | Odour | | - | specific | specific | odour free |
| 3. | pH | | - | 7.87 | 7.48 | 7.43 |
| 4. | Alkalinity | | mgCaCO$_3$/dm$^3$ | 11.8 | 3.0 | 2.4 |
| 5. | PV | | mgO$_2$/dm$^3$ | 57.6 | 42.2 | 7.32 |
| 6. | BOD | | mgO$_2$/dm$^3$ | 140 | 65 | 20 |
| 7. | COD | | mgO$_2$/dm$^3$ | 940 | 202 | 26 |
| 8. | Chlorides | | mgCl$^-$/dm$^3$ | 258.8 | 44.4 | 40 |
| 9. | Sulphates | | mgSO$_4^{2-}$/dm$^3$ | 200 | 60 | 71 |
| 10. | Phosphates | | mgPO$_4^{3-}$/dm$^3$ | 0.53 | 2.12 | 1.8 |
| 11. | Total phosphorus | | mgP/dm$^3$ | 0.63 | 2.93 | 1.9 |
| 12. | Nitrogen | Ammonium | mgN/dm$^3$ | 0.63 | 13.4 | 3.8 |
| 13. | | Nitrite | mgN/dm$^3$ | 0.07 | 0.17 | 0.18 |
| 14. | | Nitrate | mgN/dm$^3$ | 0.5 | 2.2 | 9.6 |
| 15. | | Total | mgN/dm$^3$ | 5.57 | 24.37 | 17.78 |
| 16. | Suspended solids | Total | mg/dm$^3$ | 50 | 72 | 7.4 |
| 17. | | Volatile mater | mg/dm$^3$ | 6 | 41 | 3.2 |
| 18. | | Solid parts | mg/dm$^3$ | 44 | 31 | 4.2 |
| 19. | Dissolved solids | Total | mg/dm$^3$ | 1541 | 273 | 413 |
| 20. | | Volatile mater | mg/dm$^3$ | 647 | 99 | 179 |
| 21. | | Solid parts | mg/dm$^3$ | 894 | 174 | 234 |
| 22. | Dry residue | Total | mg/dm$^3$ | 1591 | 345 | 420 |
| 23. | | Volatile mater | mg/dm$^3$ | 653 | 140 | 182 |
| 24. | | Solid parts | mg/dm$^3$ | 938 | 205 | 238 |
| 25. | Conductivity | | µS/cm | 1675 | 450 | 497 |

## DISCUSSION OF RESULTS

The amount of textile mill effluents in comparison to the amount of treated municipal sewage, constitutes only between 6 to 8.5 %. In terms however, of the organic substances load expressed as COD the load most often varies between 20 to 40 %. Some average monthly values are compared in Fig. 2.

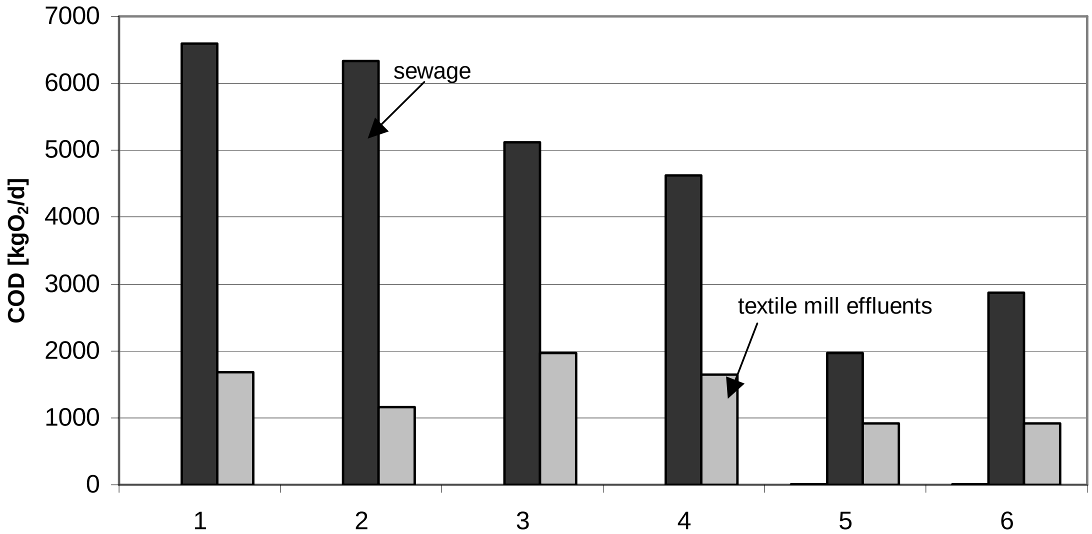


**Figure 2.** Comparison of municipal and textile wastewaters COD load.

The relatively high load of COD carried with textile mill effluents is directly related to the high value of COD. A comparison of COD values of municipal and textile wastewaters is given in Fig. 3.

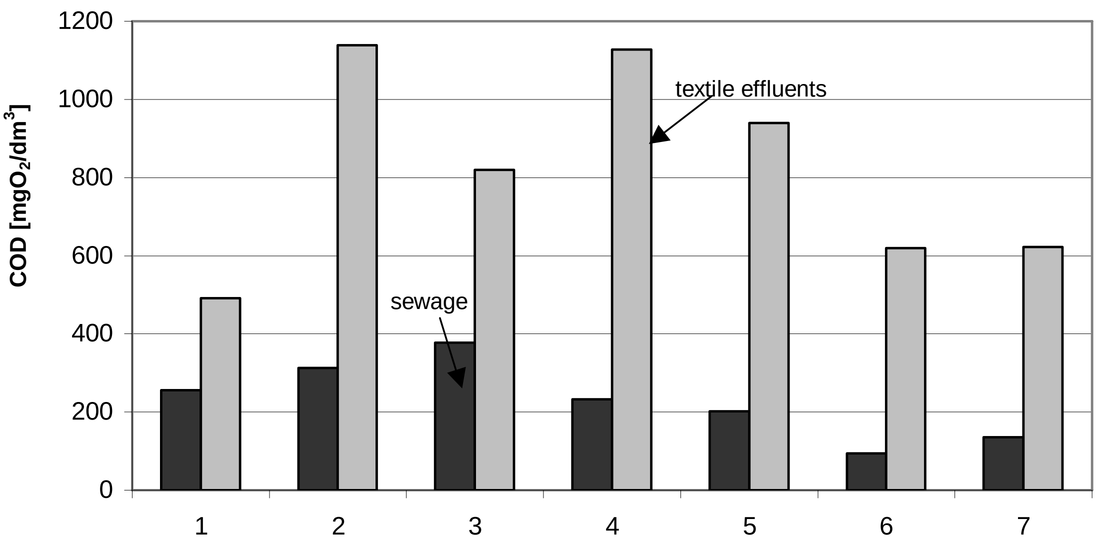


**Figure 3.** COD of municipal sewage and textile mill effluents.

As it can be seen from data given for example on Fig. 3 the values of COD of the textile wastewaters are approximately 5 times as high as that for municipal sewage. In the case of BOD the values for textile effluents are also higher than those for municipal sewage, but the ratio is only in the order of 2. Comparing the ratio of COD/BOD for textile mill effluents it can be concluded that the organic substances present are less biodegradable. The high COD/BOD ratio for textile effluents

is even more important because of relatively low values of BOD of municipal sewage, usually below 100 mg $O_2/dm^3$.
The content of nitrogen compounds and phosphates in textile mill effluents is rather low. The ammonia nitrogen concentration is in the range of 0.4 to 5.4 mg $N\text{-}NH_4^+/dm^3$. The nitrate nitrogen concentration is below 2 $mg/dm^3$. Phosphates and total phosphorous in textile mill effluents is usually below 1.0 mg $P/dm^3$. With the aforementioned low values of BOD also the content of nutrients was low. Ammonia nitrogen was in the range between 12 and 29 mg $N\text{-}NH_4^+/dm^3$, and the concentration of nitrate nitrogen in between 2.0 to 3.0 mg $N\text{-}NO_3^-/dm^3$. Also the concentration of phosphates was low, between 2 and 4 mg $P/dm^3$.
As explained earlier, the municipal sewage treatment plan was not designed for nutrients removal. Nevertheless, due to the low concentration of nitrogen compound and phosphorous it is expected to fulfil the requirements. In fact, according to the new requirements imposed by the Ministry of Environment in November 2002, only the concentration of total phosphorous is sometimes above the required concentration of 2.0 mg $P/dm^3$.
There is not necessary to remove nitrogen, and the applied at present low loaded activated sludge process, which permit partial nitrification, is adequate to fulfil the present standards.
With varying results of nitrification and phosphorous removal it was interesting to assess the impact of the textile mill effluents. As a very rough procedure for evaluation of the textile mill effluents a comparison of COD load and concentration of nitrates and phosphates in the treated combined effluent was carried out. Based on monthly average data the before mentioned correlations are shown in Fig. 4 and 5.

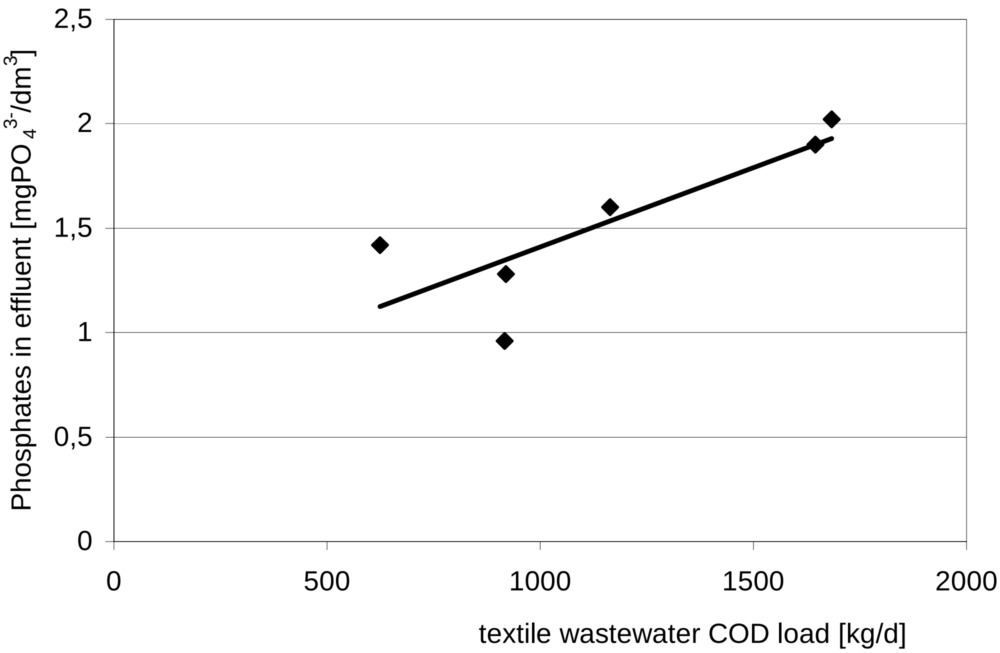


**Figure 4**. The effects of textile effluents COD load on the combined effluent phosphates concentration.

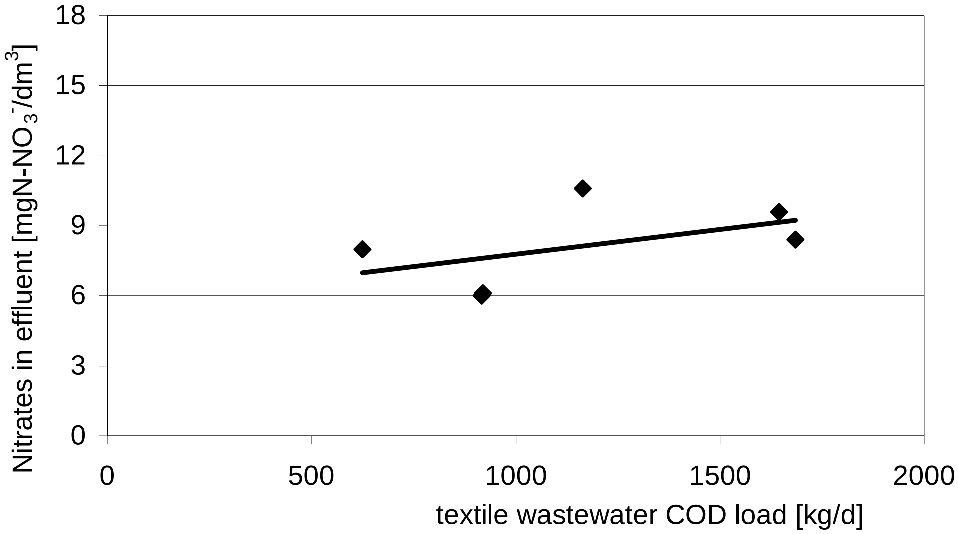


**Figure 4**. The effects of textile effluents COD load on the combined effluent nitrates nitrogen concentration.

From the above presented figures it can be concluded that with the increase of COD load introduced with textile effluents there is a decrease in the achieved results of phosphates removal. Surprisingly however an improving in the effects of nitrification could be concluded. If however the results of nitrification are presented in correlation of the COD load percentage contribution carried by textile effluents to COD load of municipal sewage, opposite conclusion can be drawn (Fig. 6.).

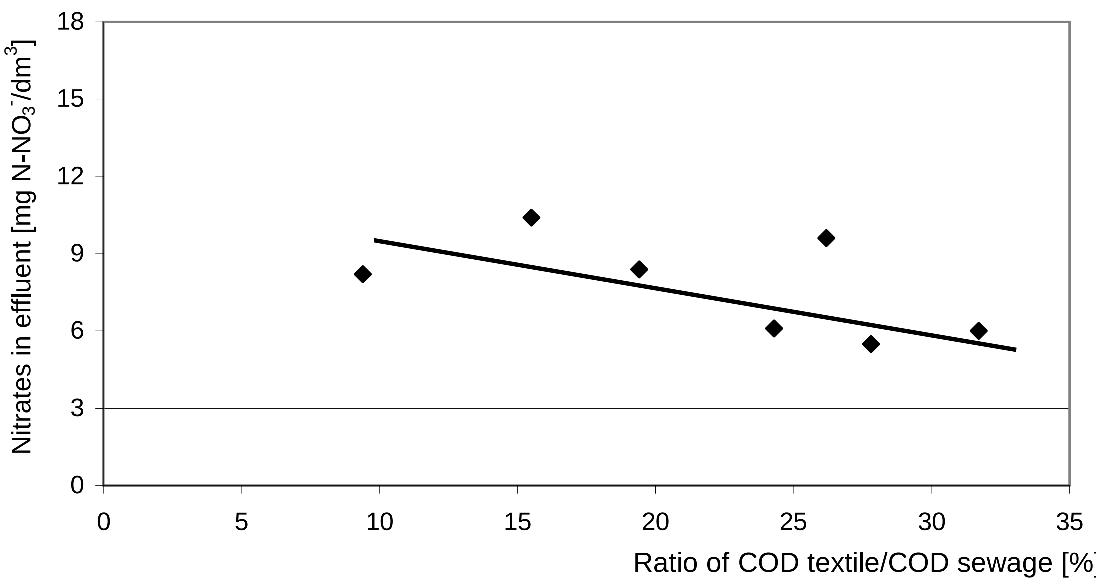


**Figure 6.** The effects of nitrification in correlation to COD-textile/COD-sewage ratio.

The carried out investigations are showing a distinct effect of textile mill effluents on the achieved results of nutrients removal. The results however, are not unanimous. In order to have a better knowledge of the biodegradability of textile effluents, laboratory scale experiments are carried out. The experiments comprise anaerobic and aerobic steps of treatment. The two step treatment process is aiming at dyes decomposition. Attention is paid to the toxicity of textile effluents and respective experiments are performed.

## CONCLUSIONS

Textile mill effluent treated in admixture with municipal sewage does have an impact not only on the obtained results of organic substances removal. Carrying high loads of low biodegradable COD also at low flow ratios to municipal sewage, the phosphorous and nitrogen removal effects are influenced. Although not unanimously, it could be concluded, that the textile mill effluents are decreasing the effects of phosphorous removal and are hindering the nitrification process.
More experiments are required and therefore laboratory scale studies are continued.

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Rozporządzenie Ministra Środowiska z dnia 29.11.2002 r. w sprawie warunków, jakie należy spełnić przy wprowadzaniu ścieków do wód lub do ziemi oraz w sprawie substancji szczególnie szkodliwych dla środowiska wodnego. Dziennik Ustaw Nr 212, Poz. 1798, 1799.