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Water Quality Assessment of the Ouled Mellouk Dam Treatment Plant, North Western Algeria

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ABSTRACT

Background: This study aims was to assess the water quality and efficiency of the Ouled Mellouk dam treatment plant (North Western Algeria). This plant consists of conventional water treatment units, like other treatment plants in Algeria, these were coagulation-floculation, sedimentation, filtration and disinfection.

Methods: The study was based on analyzes and monitoring of the main physico-chemical and bacteriological parameters of raw and treated water monthly from January to December 2018.

Result: Raw water has relatively high hardness (49°F). Turbidity was high (23.93 NTU), manganese has a max of 0.407 mg/l.These values exceeded the Algerian standards limits. Nutrients and organic matter were in increase and coliforms were present with high levels. All analysed parameters were in decrease in treated water, with the exception of sulphate which was in increase and they were within the Algerian standards. The plant has a moderate removal efficiency of 48%, with a high removal effeciency of coliforms (100%), of turbidity (94.62%) and manganese (88.69%).

Key words: Drinking water standadrs, Effeciency, Physicochemical and bacteriological parameters, Treatment plant, Water quality assessment.

INTRODUCTION

Water resources and quality are very crucial parameters, particularly in areas of severe water shortage, for urban development and ecological environment (Vörösmarty *et al*., 2010). Any development of water efficiency can effectively prevent water loss (Tupkanloo *et al*., 2016). Algeria is classified in 14th place among countries poor in water (Drouiche *et al*., 2012). Several reports show that the lack of water resources does not constitute a major cause of the insufficiency in many cases (Drouiche *et al*., 2012).

Typically, surface waters such as dams are an important part of the total potable water supply for a community (Sharma *et al*., 2018). Water quality has become a common research issue in the water resource management field due to the increased deterioration of surface and groundwater quality, as a result of pollution (Soltani *et al*., 2021). Quality assurance is necessary in water management practice to ensure safety in water application (Fadeyibi *et al*., 2018). Treatment or purification of water is considered as a critical challenge especially in developing countries since this treatment is an essential facility to conserve the public health and environment by eliminating of water borne diseases and pathogens (Hayder, 2017).This study was made to assess the water quality of the Ouled Mellouk dam treatment plant, which currently produces a treated water flow of 1800 m^3/h, of which 500 l/s was intended to supply the municipalities: Rouina, Bourached, Zeddine, El Abadia, El Mayenne and El-Attaf, with a total population of 158900 inhabitation and an estimated of 9.830 HM^3 water supply in 2018 (IWRMA, 2020). The plant was sized for a production capacity of 43,200 m^3/d for the final phase (horizon 2030) and 24 h/d of operating time (ANWC, 2021).

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MATERIALS AND METHODS

The Ouled Mellouk dam water treatment plant is located in the North-west of Algeria 36°13′25″ North latitude and 1°48′52″ East longitude (Fig 1).The plant produces a treated water flow of 1800 m^3/h (ANWC, 2021). It includes the following main treatment processes: Aeration and Pre-chlorination, Coagulation-Flocculation, Lamellar sedementation, Sand filtration and Disinfection. Sampling was carried out for raw water at inlet of treatment plant and treated water at the outlet plant once a day from January to December 2018.Samples were collected using 1 liter polyethylene (PET) bottles washed and rinsed with distilled water for physicochemical analysis and 250 ml glass vials sterilized using an autoclave for 20 minutes at

120°C to avoid contamination for bacteriological analysis (Rodier *et al*., 2009).

Temperature, pH, EC and DO were measured using HQ440d brand multi-parameter. Turbidity was measured using 2100N IS turbidimeter. The other parameters: TH, SO_4^{2-}, NH_4^+ , NO^{2-}, Fe^{2+} and Mn^{2+} were analyzed using DR 6000 absorption spectrophotometer, OM and CL^- were dosed by titration (APHA, 2012).Bacteriological parameters were carried out by the membrane filtration technique (Kanohin *et al*., 2017).

Treatment plant efficiency

The quality of raw water has a direct impact on the effectiveness of water treatment and the cost of its production and distribution (Marlena *et al*., 2012).

The average of parameters was calculated for specific periods of time by using eq. (1). The removal percentage for many averages to the raw and treated water was calculated by using eq. (2) as below: (Hussain *et al*. , 2019; Belay *et al*., 2021).

$$\text{Average } \bar{x} = \sum_1^n X_i/N \quad .....(1)$$

Where;

$\sum$ Xi= Total values of one parameter at different times.

n= Number of these parameters.

$$R_{\%} = \frac{\text{Average raw-Average treated}}{\text{Average raw}} \times 100 \quad .....(2)$$

Where;

R%= Removal percentage.

RESULTS AND DISCUSSION

Physicochemical analysis

pH was between (7.49-8.38) and (7.84-8.39) in raw and treated water. In treated water, as light decrease in pH was observed due to the quantity of coagulants added for the elimination of suspended solids and the dose of chlorineused for disinfection (Fig 2) (Hayder, 2017).

Temperature in raw water was caracterised by an increase during dry period. It was between (11.67-24.49°C). In treated water, it was between (11.97-23.17°C). It was within acceptable limits 25°C (Fig 3).

Electrical conductivity was constant during 2018. It was between (1130.58-1344.81 µs/cm) and (1133.06-1354.29 µs/cm) in raw and treated water. It was lower than Algerian standard 2800 µs/cm (Fig 4).Turbidity in raw water was between 2.31 (August) and 23.93 NTU (February).This value was higher than the standards limits (5 NTU), this might be due to the fact that the sampling period was in rainy season that can be crossly contaminated with runoffs (Wolde *et al*., 2020). In treated water, Turbidity was in decease (0.20-1.23 NTU) (Fig 5). This decrease was explained by the effectiveness of the treatments applied during the coagulation, flocculation, settling and filtration steps.

Dissolved oxygen evolution in raw water characterized by two phases (Fig 6):

- A decreasing phase from May to July with a min of 2.05 mg/l,
- An increase phase from August to December with a max of 9.8 mg/l.

In treated water, an increase of DO was reported and it was between (8.37 mg/l - 10.69 mg/l).

Organic matter contents were high in raw water, which was explained by the discharge of waste water into the Ouled Mellouk dam lake were the pollution charge estimated at 46819 Eq inhabitant (Touhari, 2015). It was between (1.92-4.0 mg/l) and (0.89-2.01 mg/l) in raw and treated water (Fig 7). However, there was a significant reduction in OM following the injection of activated carbon used to improve the organoleptic qualities of water by eliminating organic matter (Rangesh and George 2011). These values were within Algerian standard (5 mg/l).

Total hardness was relatively high, it was between (35-49°F) and (33.91 and 49°F) in raw and treated water. It was within the Algerian standard (50°F) (Fig 8). The degree of hardness of drinking water is important for esthetic acceptability by consumers, for economic and operational

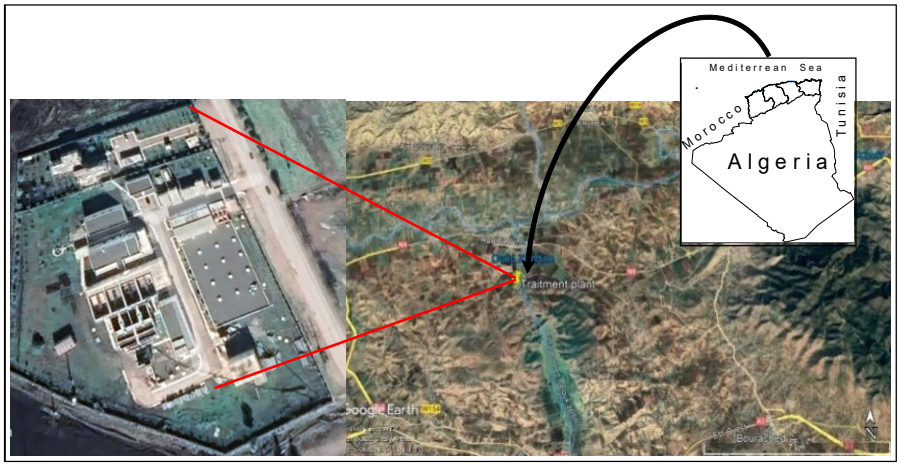

Fig 1: Treatment plant localization (Google MAP, 2022).

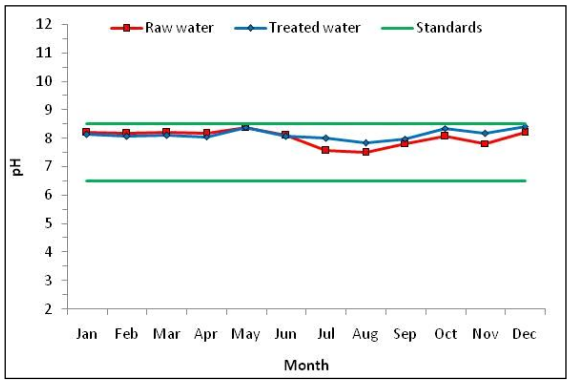

Fig 2: pH monthly evolution during 2018.

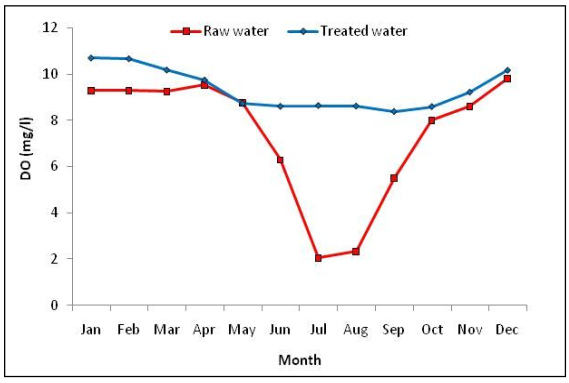

Fig 6: DO monthly evolution during 2018.

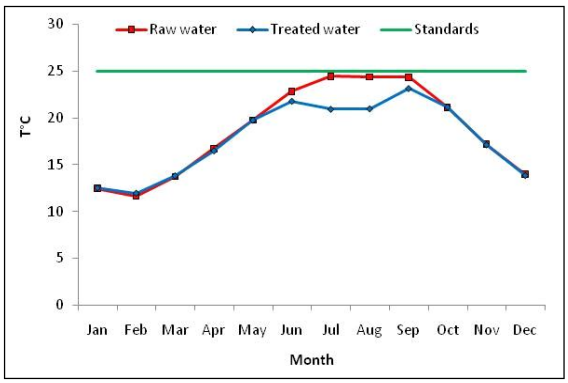

Fig 3: Temperature monthly evolution during 2018.

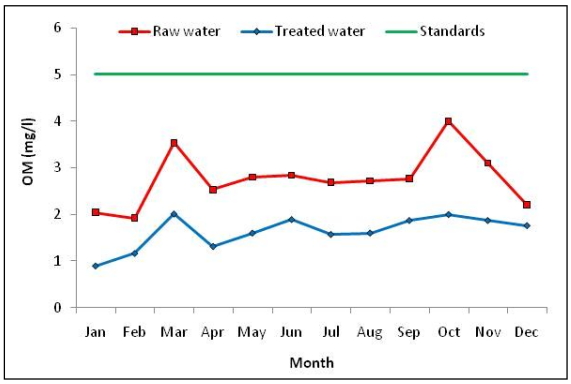

Fig 7: OM monthly evolution during 2018.

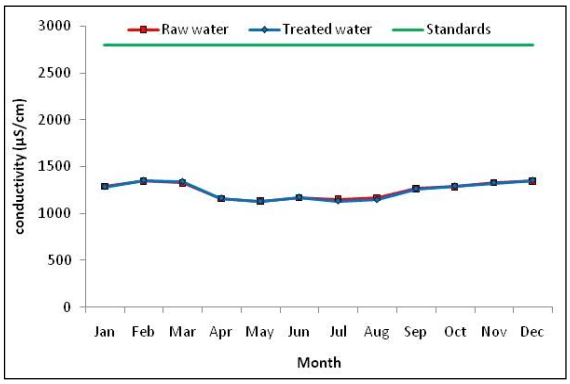

Fig 4: E.C monthly evolution during 2018.

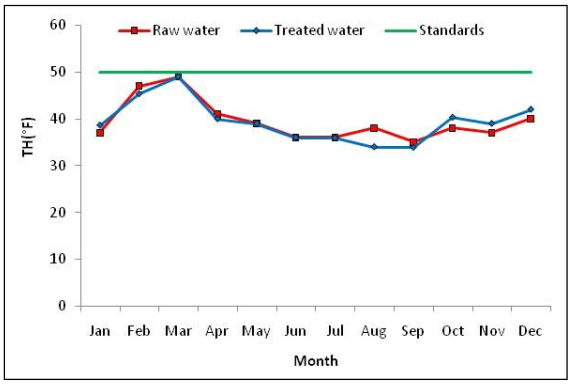

Fig 8: TH monthly evolution during 2018.

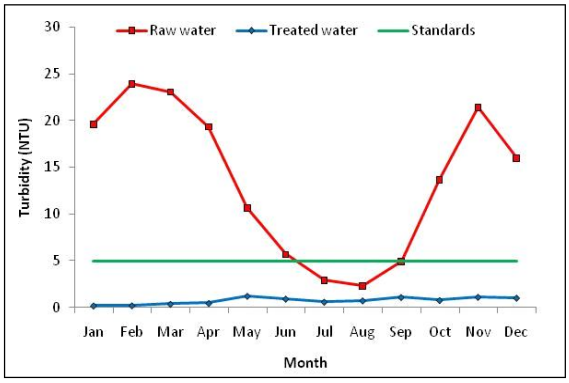

Fig 5: Turbidity monthly evolution during 2018.

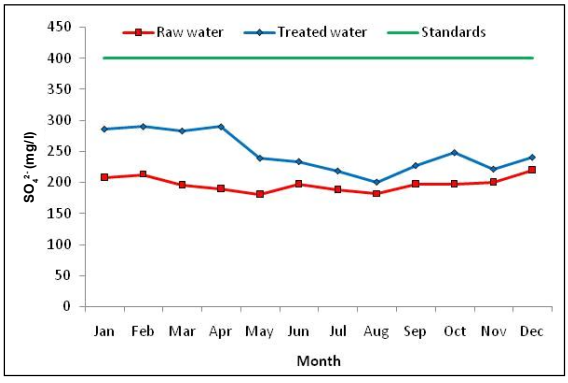

Fig 9: SO_4^{2-} monthly evolution during 2018.

consideration (WHO, 2011; Belay, 2021). Sulphate in raw water was between 181 - 220 mg/l. In treated water, it was between 200.22 and 289.77 mg/l. There was a significant increase in sulphate in treated water was due to injection of aluminum sulphate(Bahaa, 2015). It was within permissible limit (400 mg/l) (Fig 9).

Chloride in raw water was between 136.67 and 251.07 mg/l. It was between 151.86 - 247.5 mg/l in treated water and it was within the limits (500 mg/l) (Fig 10). Ammonium showed an increase in raw water with a min recorded (<0.02 mg/l) from March to August and a max of 0.13 mg/l in October (Fig 11). Similarly, nitrite showed an increase during the period from June to October with a max of 0.11 mg/l (Fig 12). The increase in these two nutrients is due to the oxidation of nitrogenous organic matter caused by wastewater discharges into the lake from the Ouled Mellouk dam. For the other months, a decrease in levels was observed following the dilution of the water by meteoric waters (Touhari, 2015).

In treated water, ammonium and nitrite were in decrease <0.02 mg/l wich due to the injection of the chlorine used during the prechlorination and desinfection. Iron and Manganese in raw water showed a significant increase during dry period,due to the presence of Fe^{2+} and Mn^{2+}ores in the Ouled Mellouk dam located upstream of the old Rouina mines (NADT, 2021), they were between (0.02-0.08 mg/l) (0.045-0.406 mg/l), (Fig 13). Noted that manganese levels recorded in the raw water were exceeded the algerian permissible limits (0.05 mg/l) with a maximum of 0.407 mg/l in september.

In treated water, results showed a decrease of iron <0.02 mg/l and manganese (0.01-0.05 mg/l), following the injection of chlorine during pre-chlorination and disinfection. This values didn't exceeded the standards limits (0.3 mg/l) for iron and (0.05 mg/l) for manganese.

Bacteriological analysis

Obtained results of bacteriological parameters in raw water (Fig 14) showed that the number of total coliforms was always greater than 200 CFU in 100 ml throughout the analysis period.Their presence in the water indicates faecal contamination due to discharges of polluted wastewater into the Ouled Mellouk dam. Pathogens in water can cause a

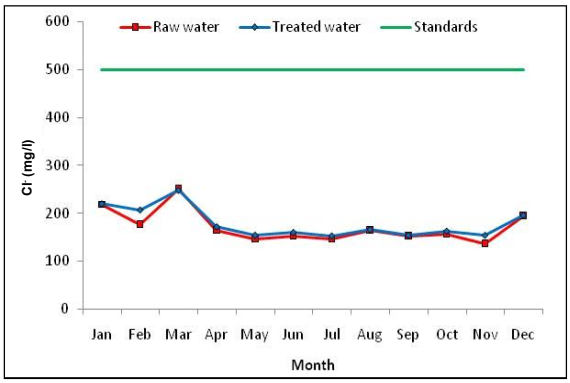

Fig 10: Cl^- monthly evolution during 2018.

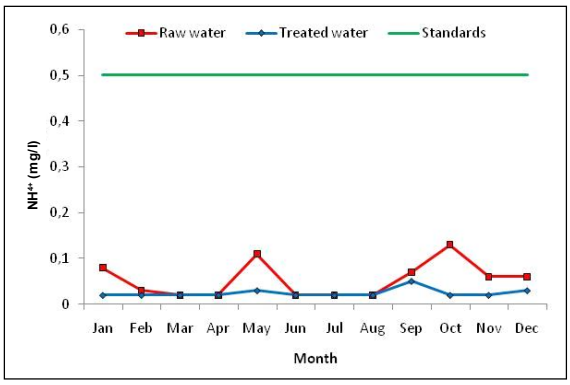

Fig 11: NH^{4+} monthly evolution during 2018.

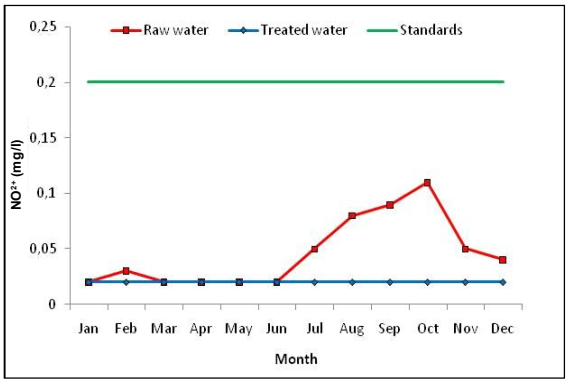

Fig 12: NO^{2-} monthly evolution during 2018.

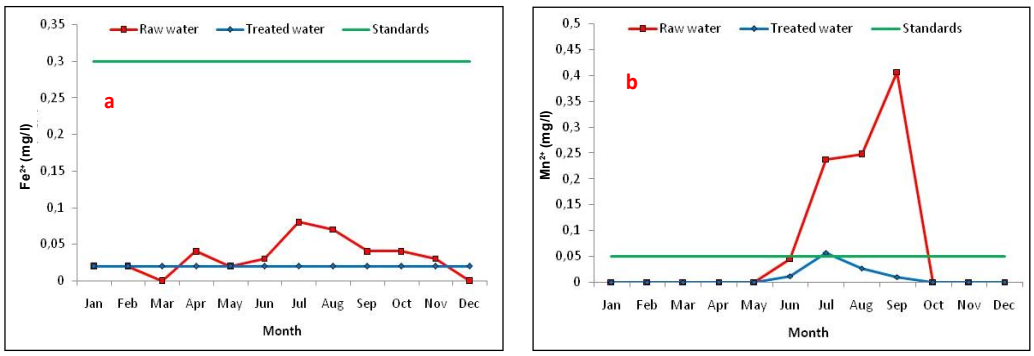

Fig 13: Fe^{2+} (a) and Mn^{2+} (b) monthly evolution during 2018.

Table 1: Average of water treatment plant efficiency, during 2018.

Parameters	Average raw water	Average treated water	Removal efficiency (%)	Algerian standards
pH	8.01	8.13	-1.45%	6.5-8.5
Turb (NTU)	13.63	0.73	94.62%	5
Cond (µS/cm)	1245.94	1249.17	-0.26%	2800
NH^{4+}(mg/l)	0.05	0.02	54.69%	0.5
NO^{3-}(mg/l)	5.86	5.78	1.35%	50
NO^{2-}(mg/l)	0.05	0.02	56.36%	0.2
PO_4^{3-}(mg/l)	0.1	0.09	12.20%	5
MO (mg/l)	2.76	1.63	41.09%	5
Fe (mg/l)	0.04	0.02	48.72%	0.3
Mn (mg/l)	0.23	0.03	88.69%	0.05
SO_4^{2-}(mg/l)	197.58	247.87	-25.45%	400
TC (CFU/100 ml)	200	0	100.00%	0
FC (CFU/100 ml)	35.83	0	100.00%	0
FS (CFU/100 ml)	5.92	0	100.00%	0
Average (%) efficiency			47.90%	

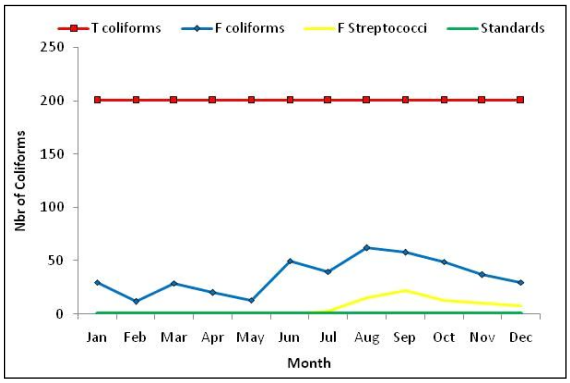

Fig 14: TC, FC and FS monthly evolution during 2018.

wide range of health problems (CAWST, 2013). Total coliforms are enterobacteriaceae that include bacterial species that live in the intestines of warm-blooded animals, but also in the environment in general (soils, vegetation and water)(Health Canada Ottawa, 2020; INSPQ, 2022).

High number of faecal coliforms, which equals 62 CFU/ 100 ml, was recorded in August and a significant number of faecal streptococci 22 CFU/100ml was recorded in September. This bacterial group, which was presented by enterococci, indicates that there was recent fecal contamination. Faecal coliforms, or thermotolerant coliforms, are a subgroup of total coliforms capable of fermenting lactose at a temperature of 44.5°C. The species most commonly associated with this bacterial group is *Escherichia coli* (*E. coli*). Although the presence of faecal coliforms usually indicates contamination of faecal origin, several faecal coliforms are not of faecal origin, coming rather from water enriched in organic matter, such as industrial effluents from the pulp and paper sector or food processing (INSPQ, 2022). The persistence of enterococci in various types of water might be greater than that of other indicator organisms (WHO, 2000), in particular because of their not orious resistance to disinfecting agents (Haslay and Leclerc, 1993). High temperature environments with a high pH contain a lot of total coliforms, faecal coliforms (Josse *et al*., 2016).

We notice total absence of all germs indicative of faecal contamination in treated water, therefore treated water is of good bacteriological quality (Gebrewahd *et al.,* 2019) and the treatment steps were effective.

Treatment plant efficiency

Table 1 showed, a removal efficiency of turbidity 94.62% which consider the highest value with manganese 88.69% comparing to other values of nitrite and ammonium (56% and 54.69%, respectively).

Results showed that organic matter, nitrate, orthophosphates and iron were not statistically significantly different at $p<0.05$ in removal efficiency and sulphate presented a negative removal efficiency with-25.45%. The standard bacteria count was very important during the water treatment process, as it allows to assess the effectiveness of the different treatment steps (Funasa, 2013). Bacteriological parameters showed removal efficiency of 100% indicating high disinfecting efficiency.

CONCLUSION

The results showed that raw water was relatively hard with high turbidity and manganese wich exceeded the Algerian standards limits. Nutrients concentrations (NH^{4+} and NO^{2-}) were in increase with organic matter excepted sulphate who showed a significant increase in treated water. Ouled Mellouk dam water is of poor bacteriological quality with total coliforms (200>CFU/100 ml), faecal coliforms (62 CFU/100 ml) and faecal streptococci (22 CFU/100 ml). In treated water, there was a decrease of all analysed parameters in treated water during 2018. The treatment plant has a moderate removal efficiency of 48%, with a high removel effeciency

of coliforms(R=100%), turbidity (R=94,62%) and manganese (R=88,69%).

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Conflict of interest

All authors declare that no conflict of interest.

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