DEVELOPING A RESORT WASTEWATER TREATMENT SYSTEM USING PLASMA TECHNOLOGY*

NGHIÊN CỨU XÂY DỰNG MÔ HÌNH XỬ LÝ NƯỚC THẢI SINH HOẠT TẠI NGUỒN KHU DU LỊCH SẦM SƠN

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ASTRACT

The resort wastewater has been not only strongly negative affected to tourist city specially rivers and beaches but also to human life in large area. It comes from original source such as hotel and restaurant which have a lot of organics, chemicals and bacteria. The disadvantages of the currently state are the using treatment systems with low treatment efficiency, costly and unstable due to using microbiological, biochemistries, combining physical chemistry method, or advanced oxidation process. In this study, a resort wastewater treatment system using plasma at low temperature and atmospheric pressure was designed and developed to solve the above disadvantages. An 480l/h treatment system was completed and assembled in the Sam Son resort, Thanh Hoa to test and evaluate the treatment efficiency. In order to prove the stability of the processing system, before and after treating, wastewater samples were collected and tested at various times. The results showed that treatment efficiency reached to 70-90% and satisfy QCVN 14: 2008/BTNMT in column A. The system is stable, low cost, safe, non-chemicals, automated and saving energy.

Keywords*: Resort Wastewater; Plasma; Atmospheric Pressure; Advanced Oxidation Process; Wastewater treatment.*

TÓM TẮT

Nước thải khu du lịch không chỉ ảnh hưởng nghiêm trọng đến du khách, dòng sông và các bãi biển mà còn ảnh hưởng đặc biệt tới cuộc sống con người trong một khu vực rộng lớn. Nó xuất phát từ các nguồn như khách sạn và nhà hàng, nơi có rất nhiều rác thải hữu cơ, hóa chất, và vi khuẩn. Nhược điểm của các phương pháp hiện nay là sử dụng hệ thống xử lý kém hiệu suất, giá cao và kém ổn định do sử dụng phương pháp vi sinh, hóa sinh, hóa lý hay các quá trình Oxi hóa bậc cao. Trong bài nghiên cứu này, hệ thống xử lý nước thải sử dụng công nghệ plasma ở nhiệt độ thấp và áp suất khí quyển được thiết kế để giải quyết nhược điểm trên. Hệ thống xử lý 480l/h được lắp đặt hoàn tất tại khu du lịch Sầm Sơn, Thanh Hóa để kiểm tra và đánh giá hiệu suất xử lý. Các mẫu nước thải được lấy và kiểm tra tại nhiều thời điểm để chứng minh sự ổn định của hệ thống xử lý. Kết quả cho thấy rằng, hiệu suất xử lý đạt 70-90% và thỏa các điều kiện QCVN 14:2008/BTNMT cột A. Hệ thống ổn định, an toàn, không hóa chất, tự động, tiết kiệm năng lượng và giá cả phải chăng.

Từ khóa*: Nước thải đầu nguồn; Plasma; áp suất khí quyển; quá trình oxi hóa bậc cao; xử lý nước thải.*

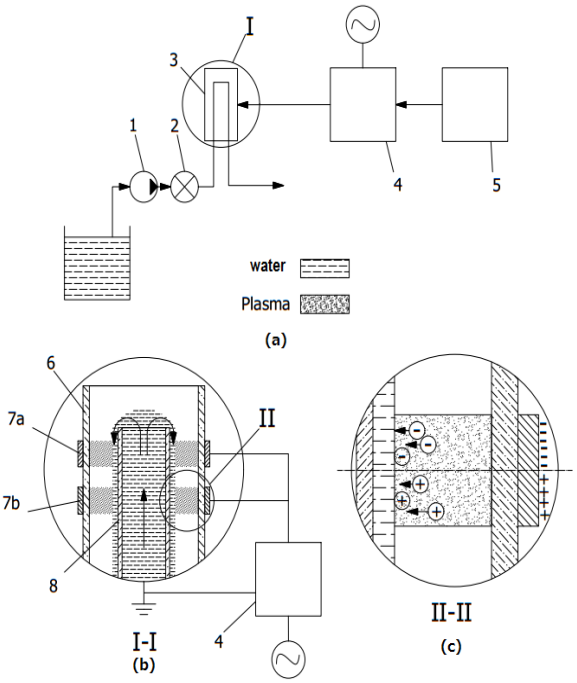
I. INTRODUCTION

The water pollution at beach and rivers in many tourist cities is currently at a high alarming level. The main pollution reasons is wastewater from the local restaurants and hotels in the resort. It contains many organic suspended solids (faces, rags, plastic

containers, peel vegetables ...) and the suspended solids in the form of glue. According to Yutaka Matsuzawa of Japan International Cooperation (JICA) in Vietnam: Domestic wastewater is the most feared environmental pollutant with a high organic content 50-55%. On the characteristics, wastewater contains a large number of micro-organisms harmful to humans. Furthermore, another facilities in tourist cities are also added yet more pollutants to the water. The level of pollution will affect a very long stretch of the river and beach for many years to come. The recent survey of wastewater in Sam Son has used experimental techniques and applied scientific technology to get a true picture of how bad the pollution is in the air, water and land. However, the recent investments in current treatment methods are not yielding the needed results. Technological solutions for wastewater treatment in developed countries have reached a high level [1-4] but it have not applied in developing countries. Although the world is very diverse in processing, the technology is still based on three principles: chemistry, biology and membrane filtration technology. Moreover, the currently available treatment methods are costly, low-performance, complex, multiple chambers, chemical consuming, secondary negative effect and low efficiency due to using medical microbiology methods, advanced oxidation process or combined between chemical and biochemical methods [5-8]. The JOHKASOU (Japan technology), Bio-Sac system (Korea technology) and another methods (chemical and biochemical methods) from European countries have many advantages such as energy saving, high efficiency and easy to control automatically. However, the disadvantage of these system are the large investment cost, large area, and requires tight concentration and input flow water. Moreover, the maintenance cost also is high. Using plasma is revolutionary method to solve above problems. Dynamic electrons and the principles of oxidization in plasma reactors are two main factors that clean water [9-12]. In this study, the atmospheric pressure and low temperature plasma system is used to treat resort waste water replaces use bio and chemical is introduced. This only uses the physic of electricity therefore friendly with the environment and human health.

II. EXPERIMENTAL SETUP

An experimental resort wastewater treatment process was designed and manufactured. The system consists of a pump (1), flow valve (2), plasma reactor (3), power supply (4), and program logic controller (5) as shown in Fig. 1(a). The wastewater is continuously pumped into reactor. Two electrodes are connected to 10-40kV and 20-75 KHz. A PLC controls the automatic process of system. After treating by plasma, wastewater is coagulated and loculated by alum. After treating, clean water flows to sewer system of the city. The plasma reactor consists of ten parallel processing modules and each module is shown in Fig.1(b,c). The single plasma processing module consists of two different diameter dielectric tubes (6, 8). Outer tube is tied by two electrodes (7) and connected to the anode of the power supply. Figure 1 (d,e) shows the automated system using for Hai Yen Resort in Sam Son, Vietnam with treated capacity 480l/h. The parameter of system is shown in Tab. 1.



(d) (e)

Figure 1. *A resort wastewater treatment system; treatment processing (a), a module reactor (b), plasma treatment mechanism(c), model treatment system (d) and real treatment system (e).*

Applied power and stable system were used for studying the treatment efficiency, comparing to the standard of Vietnam 14:2008/BTNMT in column A. Six samples were collected (different water sources) and analyzed under various applied powers. The results are measured at the Testing Laboratory–Experiment and Application of Science and Technology Sam Son by the test method ISO 6060:1989 and SMEWW 1220C. Moreover, four wastewater samples at Hai Yen Resort are also used to evaluate stability through data of before and after treating with at one hour, two hours and three hours.

Table 1. *Parameters of system.*

Treated capacity: 480l/h	Power: P = 1.2 KW/h
Temperature: 30^0C-40^0 C	Input power: 220 V, 60Hz
Dimention: 1,5x0.7x0.7 m	Automatic control
Weight: 50 Kg	Material: INOX, PYRES

III. RESULT AND DISCUSSION

A. Determine the wastewater's properties from Sam Son City-Resort city (Average)

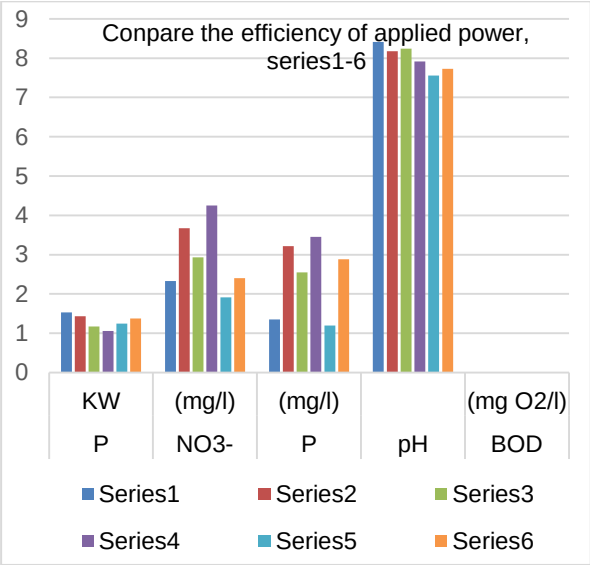
Table 2. *Average of six samples's properties*

Items	Unit	Untreat (average)	QCVN 14:2008 (A)
pH		7.43	5-9
BOD_5 (20^oC)	mg/l	**61.8**	30
TSS	mg/l	**145**	50
Total dissolve solids	mg/l	**900**	500
Sunfua (base on H_2S)	mg/l	**3.25**	1
Amoni (base on N)	mg/l	**16.5**	5
Nitrat (NO_3^-) (base on N)	mg/l	5.77	30
Oil	mg/l	**33.3**	10
Total surfactants	mg/l	**23**	5
Phosphat (PO_4^{3-}) (base P)	mg/l	1.52	6
Coliforms	MPN/ 100ml	**26666**	3000

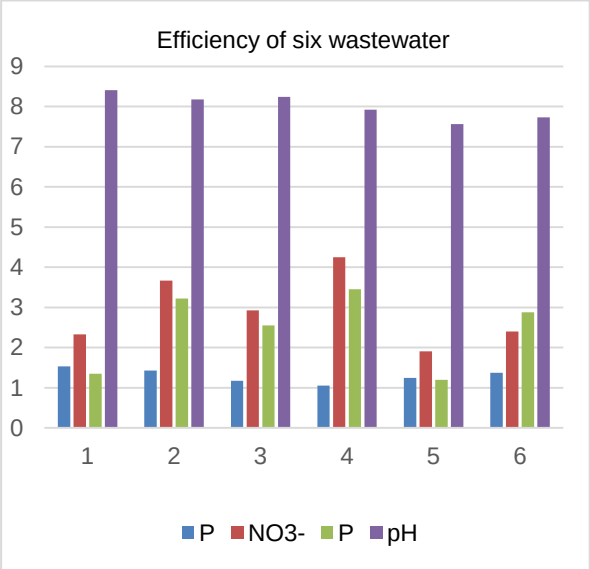
Six wastewater samples from different resorts around Sam Son city were collected and analyzed before plasma treating, the properties of wastewater were determined as shown in TABLE II. About the initial perception, the wastewater samples are grayish-white, opaque, reeky and irritating. The results showed that 8/11 quotas (bold text in TABLE I) exceed the standard of Vietnam 14:2008/BTNMT in column A, in which coliforms and surfactants were higher 8.89 and 4.6 times compared to the permitting standard. The BOD5, TSS, Oil is higher 2.06, 2.9 and 3.33 times, respectively. The sunfua is higher 3.25 times. Total dissolve is higher 1.8 times. The amoni is higher 3.3 times. These results showed that the resort wastewater in tourist city was seriously polluted include inorganic and organic. The above assessments will be the basis for select wastewater treatment technology.

B. Dependence of treatment efficiency on applied powers

In this study, all six wastewater samples, each ones is applied six input power levels 1.2, 1.5KW were used. And four properties were chose to evaluate the treatment efficiency. The results are shown in TABLE III.



(a)



(b)

Figure 2. *Dependence of treatment efficiency on applied powers (a,b).*

The result showed that the treatment efficiency follow sin chart in all case of experiments, the best productivity achieved at 1.2KW (1,31A, 95V). In general, the treatment efficiency is quite high, especially for initial pollution quota exceeds the permitting standards. In this power, all quotas reduce after treating and reach the permitting standards, the standard of Vietnam 14:2008/BTNMT in column A. Therefore, 1.2KW is selected to apply for the treatment system.

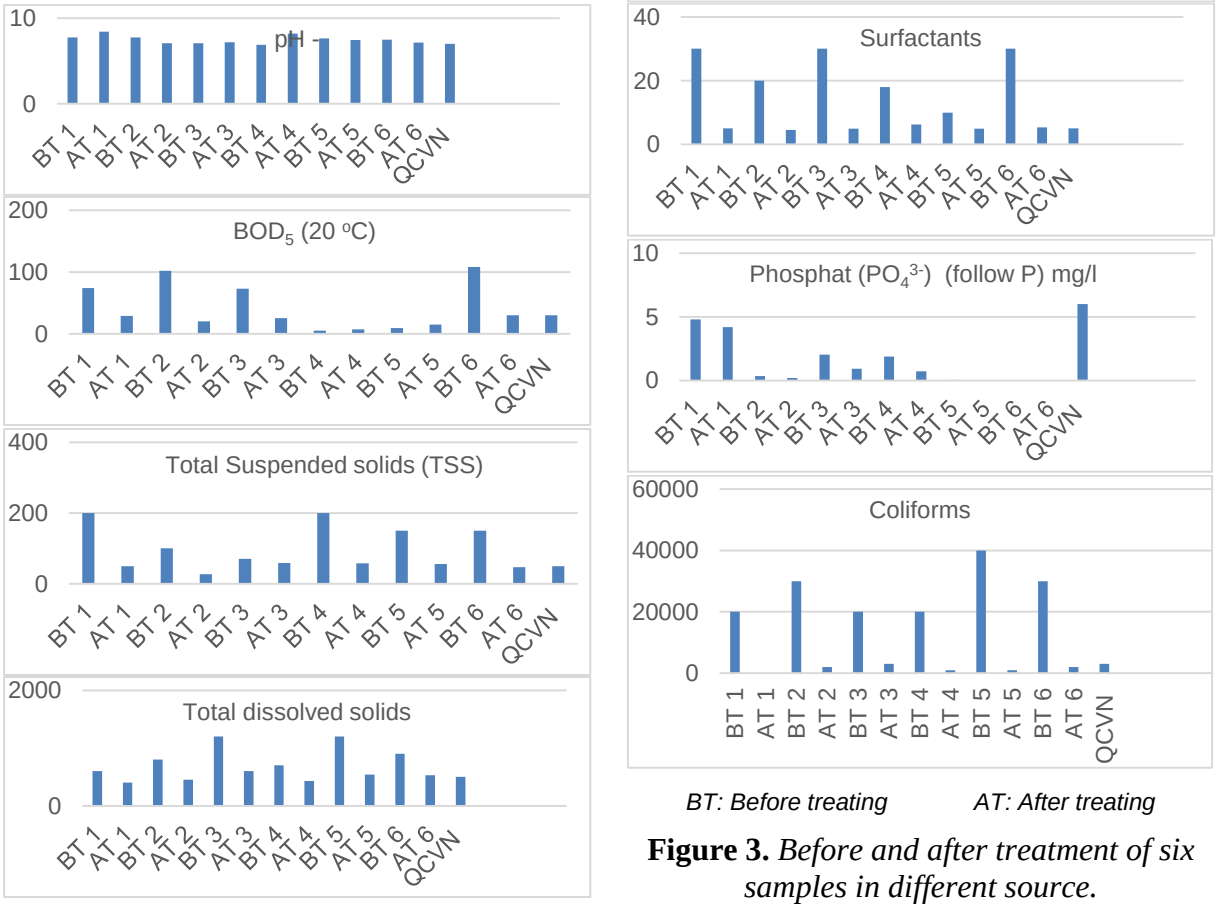
Table 3. *Six samples under various applied voltage and amperage.*

Amperage and voltage			**Measurable indicators**						
			After treatment			**Before treatment**			
I	U	P	NO3-	P	pH	NO3-	P	pH	BOD
A	V	KW	mg/l	mg/l		mg/l	mg/l		mgO2/l
1.39	110	1.5	2.3	1.35	8.41	6.8	4.8	8	74
1.43	100	1.4	3.7	3.22	8.18				
1.3	90	1.2	2.9	2.55	8.24				
1.32	80	1.1	4.3	3.45	7.92				
1.31	95	1.2	1.9	1.2	7.56				
1.31	105	1.4	2.4	2.88	7.73				
1.39	110	1.5	0.3	0.19	7.08	0.7	0.4	8	102
1.43	100	1.4	0.4	0.27	7.32				
1.3	90	1.2	0.4	0.21	7.24				
1.32	80	1.1	0.5	0.3	7.26				
1.31	95	1.2	0.2	0.15	7.05				
1.31	105	1.4	0.3	0.25	7.12				
1.39	110	1.5	7.2	0.92	7.2	15	2	7	73
1.43	100	1.4	8	1.2	7.26				
1.3	90	1.2	6.5	0.82	7.15				
1.32	80	1.1	8.4	1.37	7.36				
1.31	95	1.2	5.8	0.62	7.05				
1.31	105	1.4	5.9	0.87	7.13				
1.39	110	1.5	2.6	0.74	8.19	5.8	1.9	7	5
1.43	100	1.4	2.9	0.92	7.83				
1.3	90	1.2	2.8	0.63	7.59				
1.32	80	1.1	1.3	0.35	7.27				
1.31	95	1.2	2.4	0.76	7.93				
1.31	105	1.4	2.1	0.54	7.38				
1.39	110	1.5	3.9	0.01	7.46	6.5	0	8	9
1.43	100	1.4	4.7	0.01	7.5				
1.3	90	1.2	3.3	0.01	7.34				
1.32	80	1.1	4.4	0.02	7.78				
1.31	95	1.2	2.7	0	7.13				
1.31	105	1.4	2.9	0	7.23				
1.39	110	1.5	0.5	0	7.15	0.8	0	7	108
1.43	100	1.4	0.4	0	7.38				
1.3	90	1.2	0.5	0	7.29				
1.32	80	1.1	0.6	0	7.43				
1.31	95	1.2	0.2	0	7.03				
1.31	105	1.4	0.3	0	7.12				

The treatment efficiency of 11 quotas at 95V and 1,31A are shown in Fig.3. the BOD professing efficiency reached 100%, NO3- is 71,7% and 75% is for P ingredient, pH reached 7,73. All of those satisfy QCVN 14:2008/BTNMT in column A.

C. Dependence of treatment efficiency on resort wastewater types

Figure 3 shows the results of 11 quotas of six resort wastewater types before and after treating at 95V and 1,31A. The results show that wastewater's properties were significantly improve after treating. The treatment system is suitable for all type of samples. Although wastewater were treated with high efficiency, some sample's quotas still exceed the QCVN 14:2008/BTNMT in column A. The cause of exceeding are the unstable of collected samples by time. Some samples were collected at weekend or holiday when number of tourists in resort is high volume and very dirty. Therefore after treating samples's properties exceed the permitting standard.



BT: Before treating *AT: After treating*

Figure 3. *Before and after treatment of six samples in different source.*

As the result in Fig. 4. the quotas of TSS and Amoni exceed the permitting standard. However, the average samples's properties after treating is satisfy QCVN 14:2008/BTNMT in column A as shown in Fig. 5. In conclusion, the wastewater source constantly in time, the quality of water after treating will stably reach the QCVN 14:2008/BTNMT.

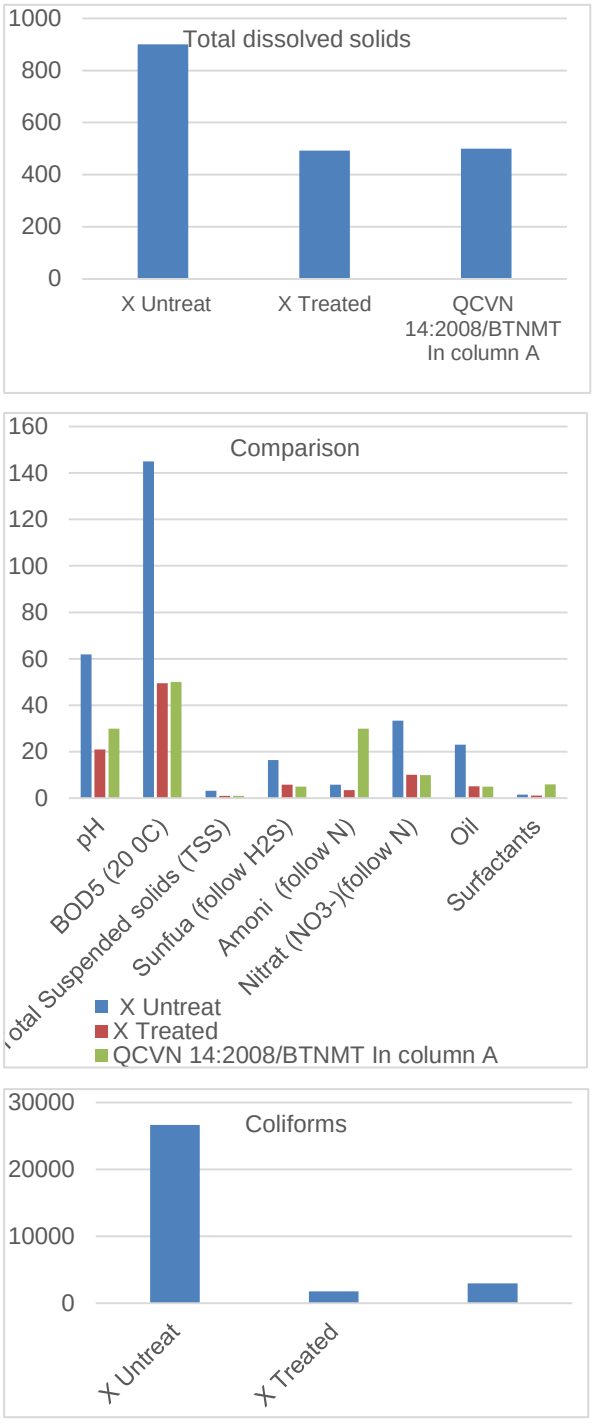


Figure 4. *Average of six samples compare with QCVN.*

D. The stability of the system

Table 4. *Evaluate the change of treatment system among three hour.*

Analysis (Unit)	Treated 1h	Treated 2h	Treated 3h	Treated 4h	Untrea	QCVN 14
Color (Pt/Co)	3	3	3	3	75	50
BOD5 (20^0C) (mg/l)	2.4	2	2.4	4	14	30
TSS (mg/l)	55.3	51.7	50.6	51.3	121	50
Amoni (N) (mg/l)	0.5	0.7	0.8	0.5	4.2	5
Oil (mg/l)			0	0.02	0.01	10
Nitrat (NO_3^-) (N) (mg/l)	0.68	0.85	0.26	1.15	1.15	30
Phosphat (PO_4^{3-}) (P) (mg/l)	0.66	0.03	0.63	0.67	0.68	6
H_2S/S^{2-} (mg/l)	0	0	0	0	4	1
Coliforms (MPN/100ml)	43	11	93	110	200000	3000

To assess the stability of the system, an 480l resort wastewater system is placed in Hai Yen Resort to evaluate the stability of the system with time. Four treated samples were took after 1,2,3 and 4 hours to check and the results are shown in TABLE IV. In the first hour, the content of color and coliforms significantly change between before and after plasma treating, color is 96% and coliforms is almost 100% and reached the permitting standard. However, the content of TSS still exceed the permitting standard, the efficiency of TSS is about 55%. In the second hour, the content of wastewater satisfy the QCVN 14:2008/BTNMT in column A except TSS, but its efficiency improve to 57%. In the third hour, the efficiency of TSS continue increases to 59% and reaches the permitting standard. Table IV. shown the stability of the system during three hours, treatment efficiency stably remains during four hours.

IV. CONCLUSION

In this paper, the wastewater at resort around Sam Son tourist city was determined. A resort wastewater treatment system was developed, installed and operated in a real resort by plasma technology with capacity 480l/h to evaluate the treatment efficiency. Applied power is the main treatment efficiency factor, the best applied power

achieved at 1.2kW (1,31A, 95V). The system is portable about 1,5x0.7x0.7m, stable, automated, and save energy about 1.2 to 1.5 kW/h. The system works well immediately after installing and stable with time. All quotas of wastewater after treating reach QCVN 14:2008 in column A. With plasma technology, the system is simply operation, low cost and especially not only high efficiency but also non-chemical.

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