

INTRODUCTION

The improper disposal of unused prescribed medications is a major abuse, safety, and environmental issue. The Deterra™ Drug Deactivation System offers a unique disposal method to deactivate unused, residual or expired medications and showed a significantly better deactivation effect compared to cat litter and coffee grounds [1]. The system basically consists of a drug disposal pouch which contains granular activated carbon packaged within a water soluble film reservoir. This pouch can render drugs inactive by adsorption in the presence of water which is simple and convenient for the patients. In the present study, efficiency of this disposal system was tested with five types of psychoactive medications using different dosage forms such as sublingual films, liquid and solid dosage forms.



Figure 1: A) Traditional methods of drug disposal as recommended by FDA. **B)** Deterra™ Drug Deactivation Pouch

METHODS

Adsorption Study

- S1: Medications were added to Deterra™ Drug Deactivation Pouches
- S2: 50mL warm (~43° C) tap water was added to each pouch
- S3: Pouches were stored upright and undisturbed in the cabinet at room temperature
- S4: Samples were collected at 8h, 1, 2, 4, 7, 14, 21 and 28 days and samples were analyzed by High Performance Liquid Chromatography (HPLC)

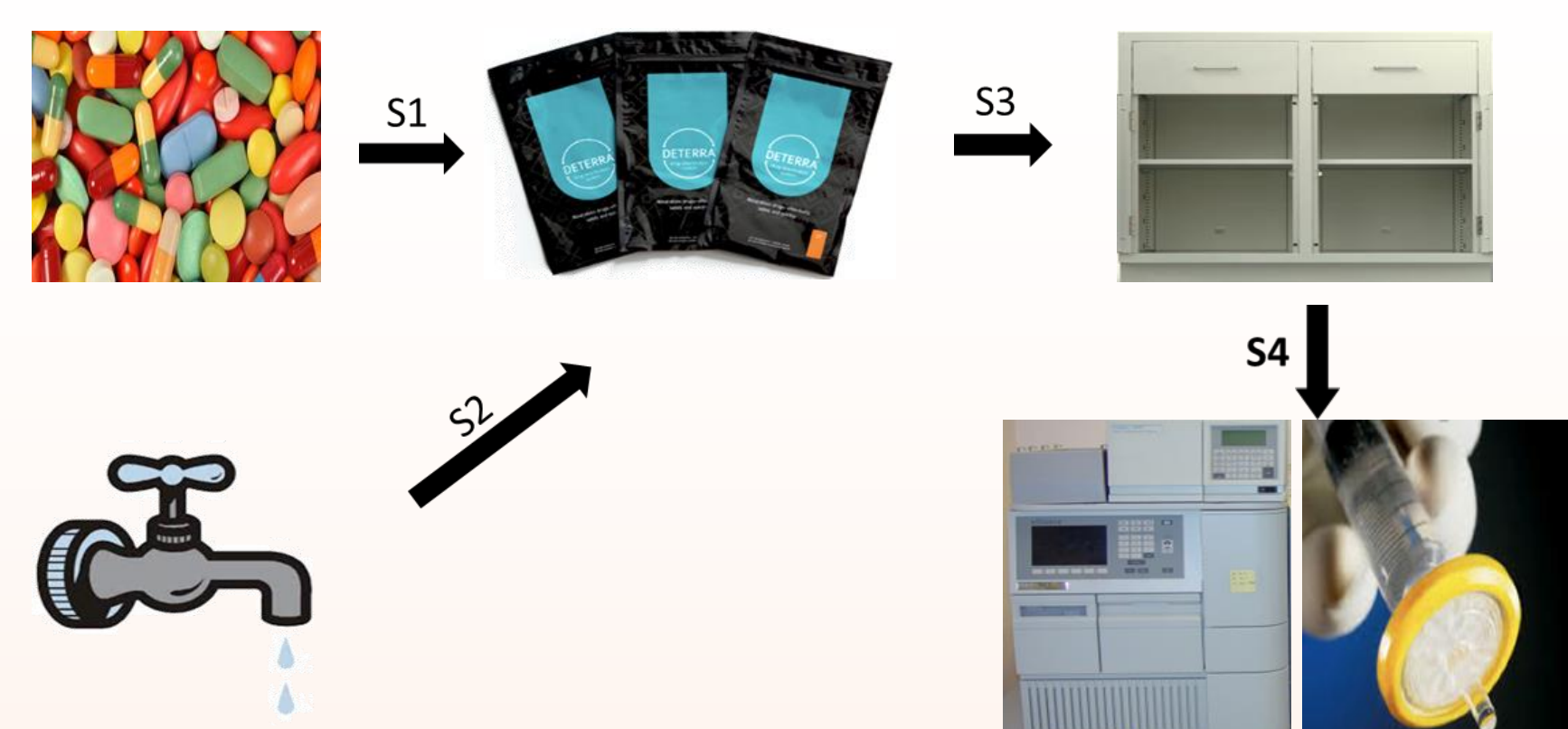


Figure 2: Adsorption study of psychoactive medications

Desorption Study

- S1: At 28th day, entire contents of each pouch were transferred into container and 200mL distilled water was added to the contents.
- S2: Samples were rocked for 1 hour at 150rpm and stored upright, undisturbed at room temperature for 23 hours
- S3: Samples were collected at 29th day
- S4: Water in the pouch was replaced with 30% ethanol
- S5: Samples were shaken for 1 hour at 150rpm and stored properly at room temperature for an additional 23 hours.
- S6: Samples were collected on 30th day and all samples were analyzed by HPLC.

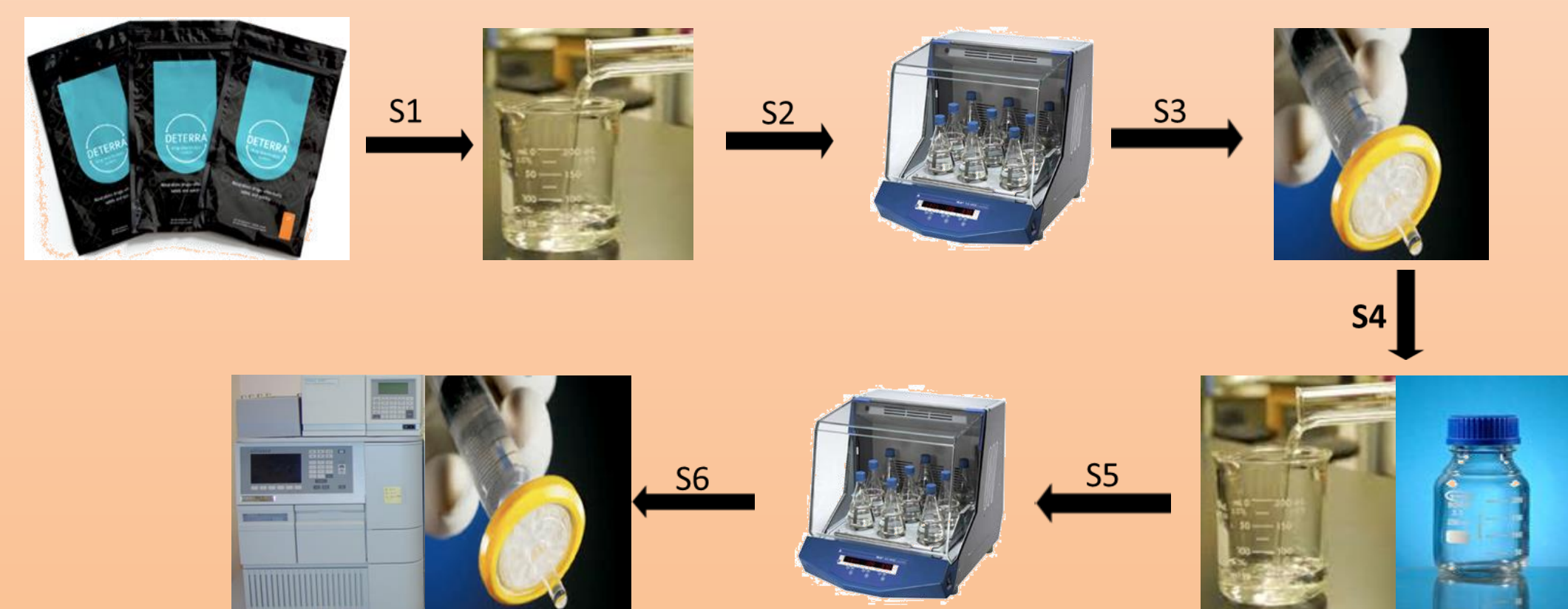


Figure 3: Desorption study of psychoactive medications

RESULTS

Deactivation started immediately after addition of the medications into the disposal pouches. As seen in Fig. 5, within 8 hours, approximately 81.81% of medications were adsorbed by the activated carbon. Morphine and buprenorphine showed much higher deactivation rate of approximately 99% within 8 hours. Medications continued to be adsorbed over time with an average total adsorption of 97.44% by 14 days. By the end of 28 days, 95% drug substances had been deactivated. For morphine and buprenorphine, almost 100% of drug was adsorbed by the granular activated carbon. In case of the desorption study, less than 1.6% of the active ingredients leached out from the activated carbon as shown in Fig.7

	Fluoxetine	Buprenorphine	Morphine	Diazepam	Oxycodone
Column	Kinetex 5u EVO C18 100A, 250x4.6mm	Kinetex 5u EVO C18 100A, 150x4.6mm	Kinetex 5u EVO C18 100A, 150x4.6mm	Kinetex 5u EVO C18 100A, 150x4.6mm	Kinetex 5u EVO C18 100A, 250x4.6mm
Mobile Phase	ACN: 40% Phosphate buffer: 60%	ACN: 83% Phosphate buffer: 17%	ACN: 10% NH ₄ OAc buffer: 90%	Methanol: 60% Phosphate buffer: 40%	ACN: 8% NaH ₂ PO ₄ buffer: 92%
Flow Rate (mL/min)	1.0	1.0	1.0	1.0	1.2
Injection Volume (µl)	10	10	30	10	10
Wavelength (nm)	226	212	285	230	205
Retention Time (min)	~3.4	~3.5	~4.0	~5.0	~9.0

Table 1: HPLC assay method for five drugs

Time (Days)	% Medications Reacted					
	Fluoxetine	Buprenorphine	Diazepam	Morphine	Oxycodone	Average
0	0	0	0	0	0	0
0.33	88.36	95.15	46.25	99.84	84.26	82.77
1	89.68	95.64	50.76	99.85	85.00	84.19
2	91.49	98.56	72.07	99.99	86.67	89.76
4	89.68	99.54	73.43	99.99	92.05	90.94
7	91.49	99.78	74.17	99.99	97.51	92.59
14	95.3	99.95	90.04	100.00	99.79	97.02
21	91.04	99.99	94.87	100.00	99.80	97.14
28	94.37	100.00	99.32	100.00	99.91	98.72

Table 2: Adsorption study results over 28 days

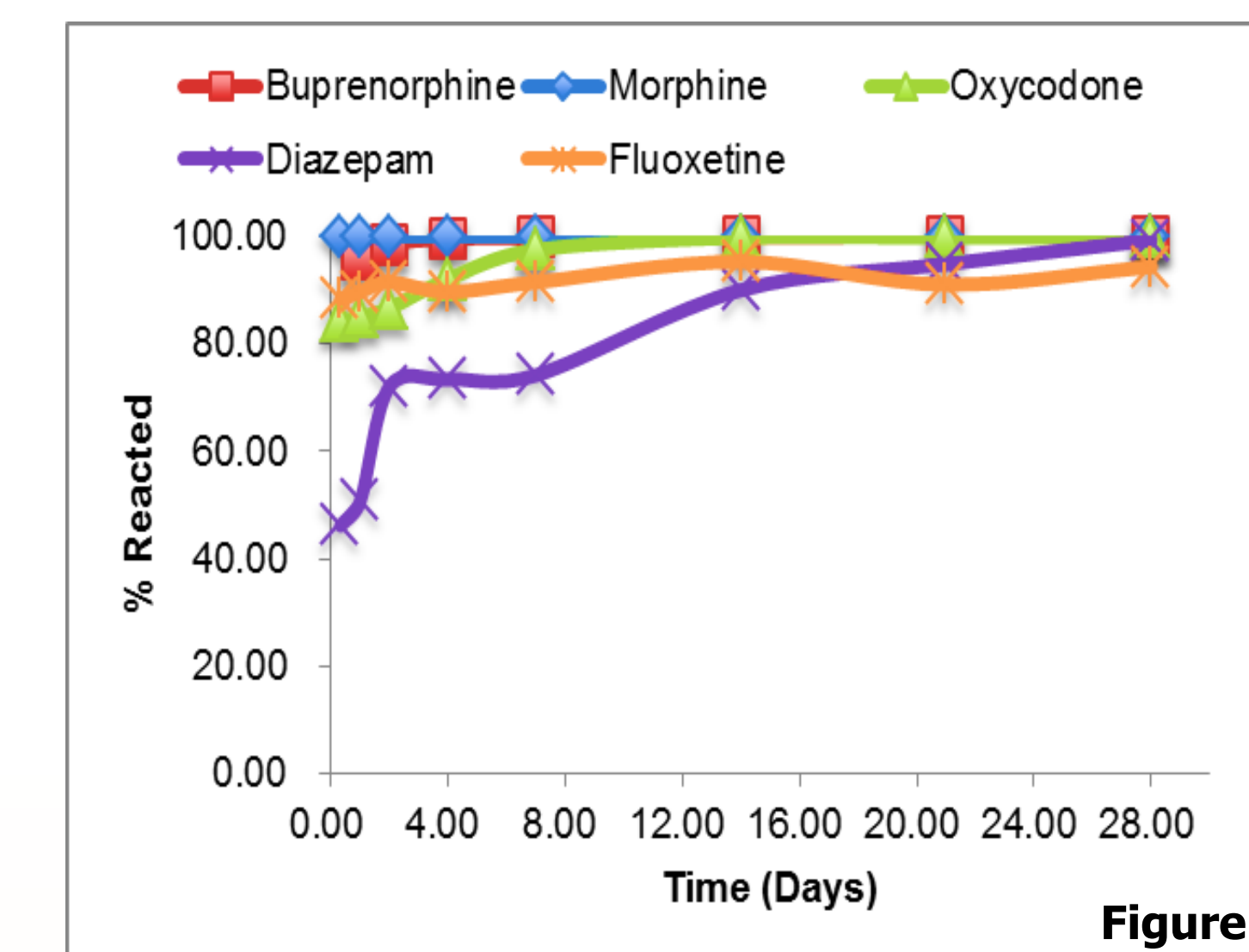


Figure 4: Deactivation of oxycodone, morphine, buprenorphine, diazepam and fluoxetine.

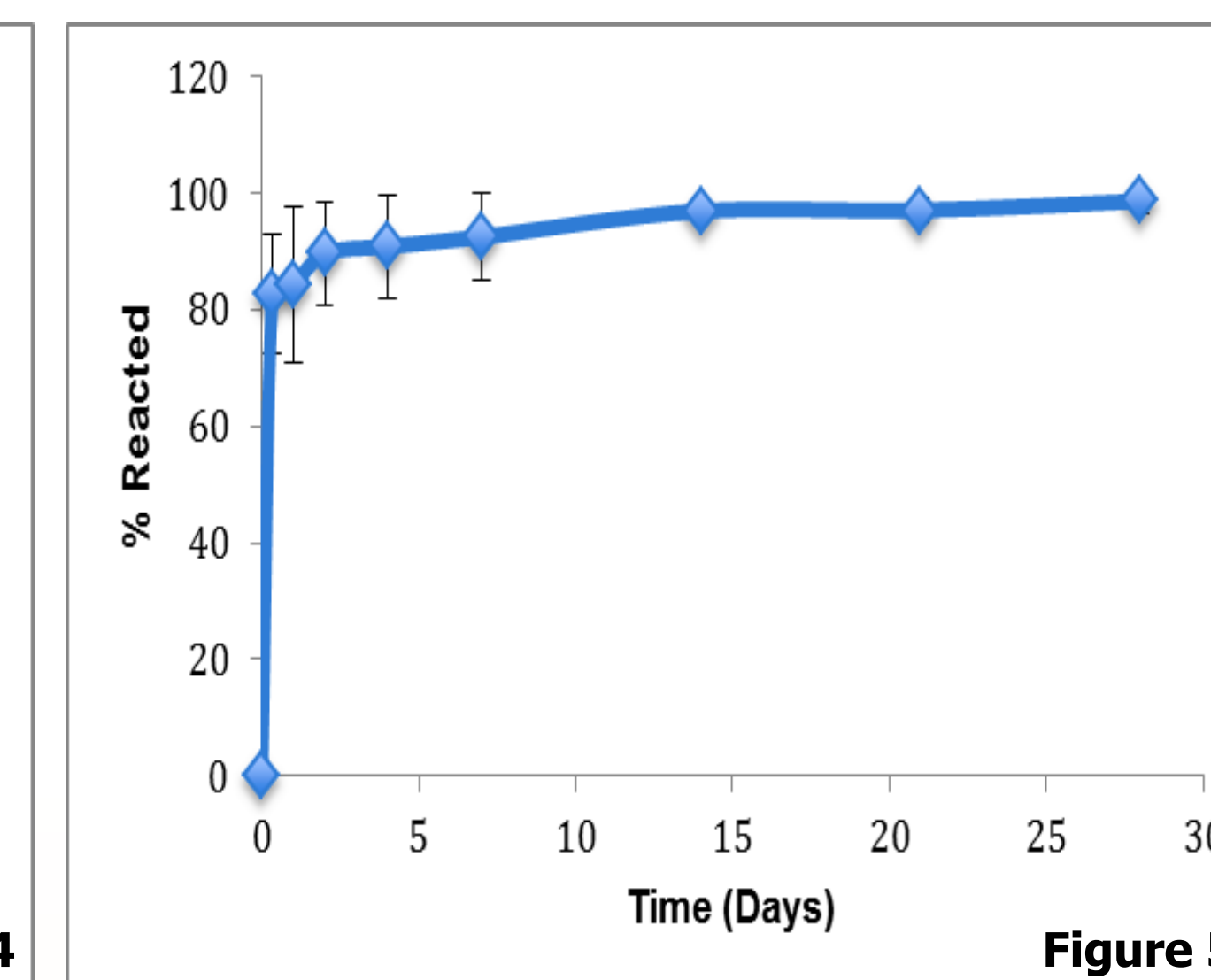


Figure 5: Average % of deactivation of five medications

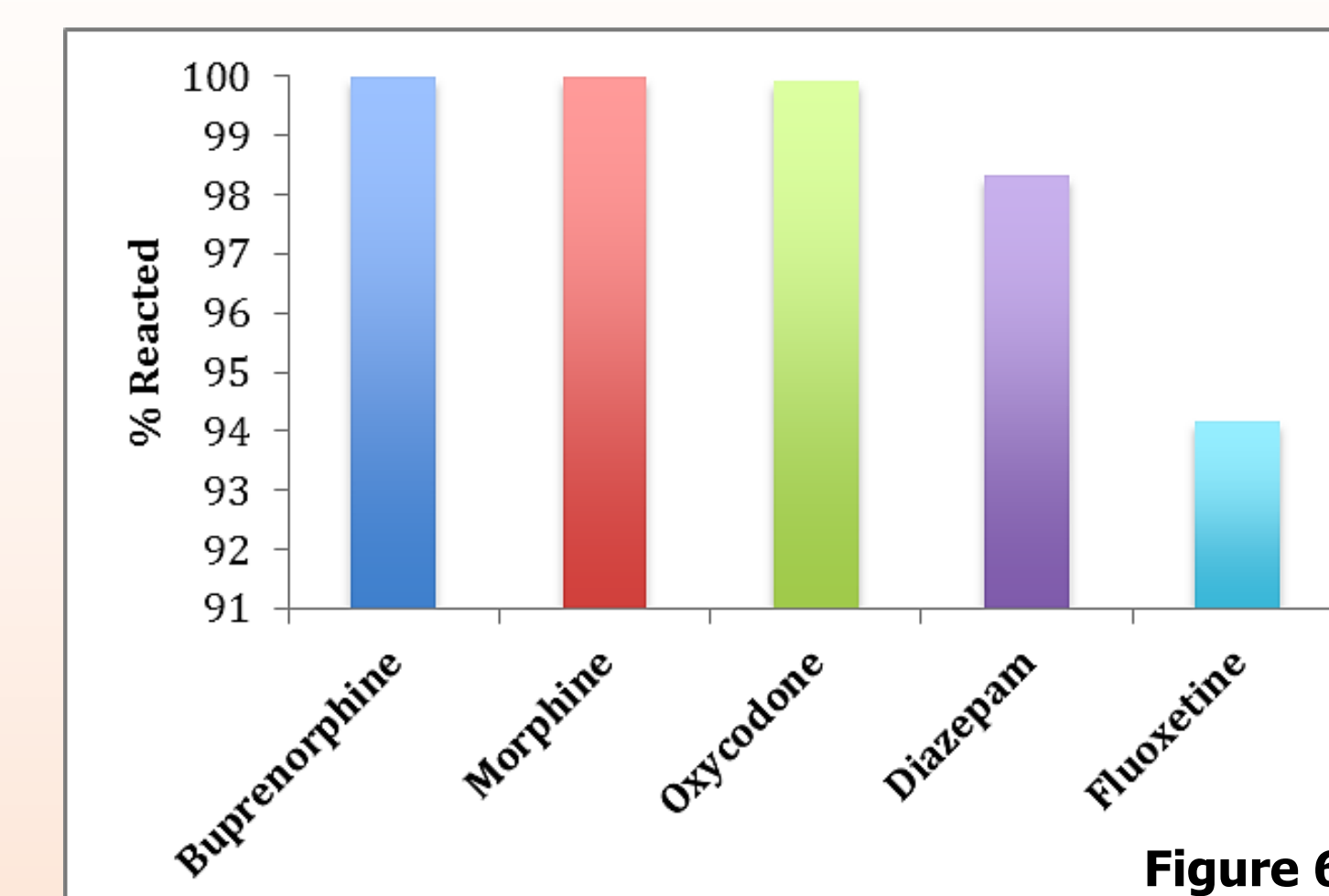


Figure 6: Desorption study of oxycodone, morphine, buprenorphine, diazepam and fluoxetine in water

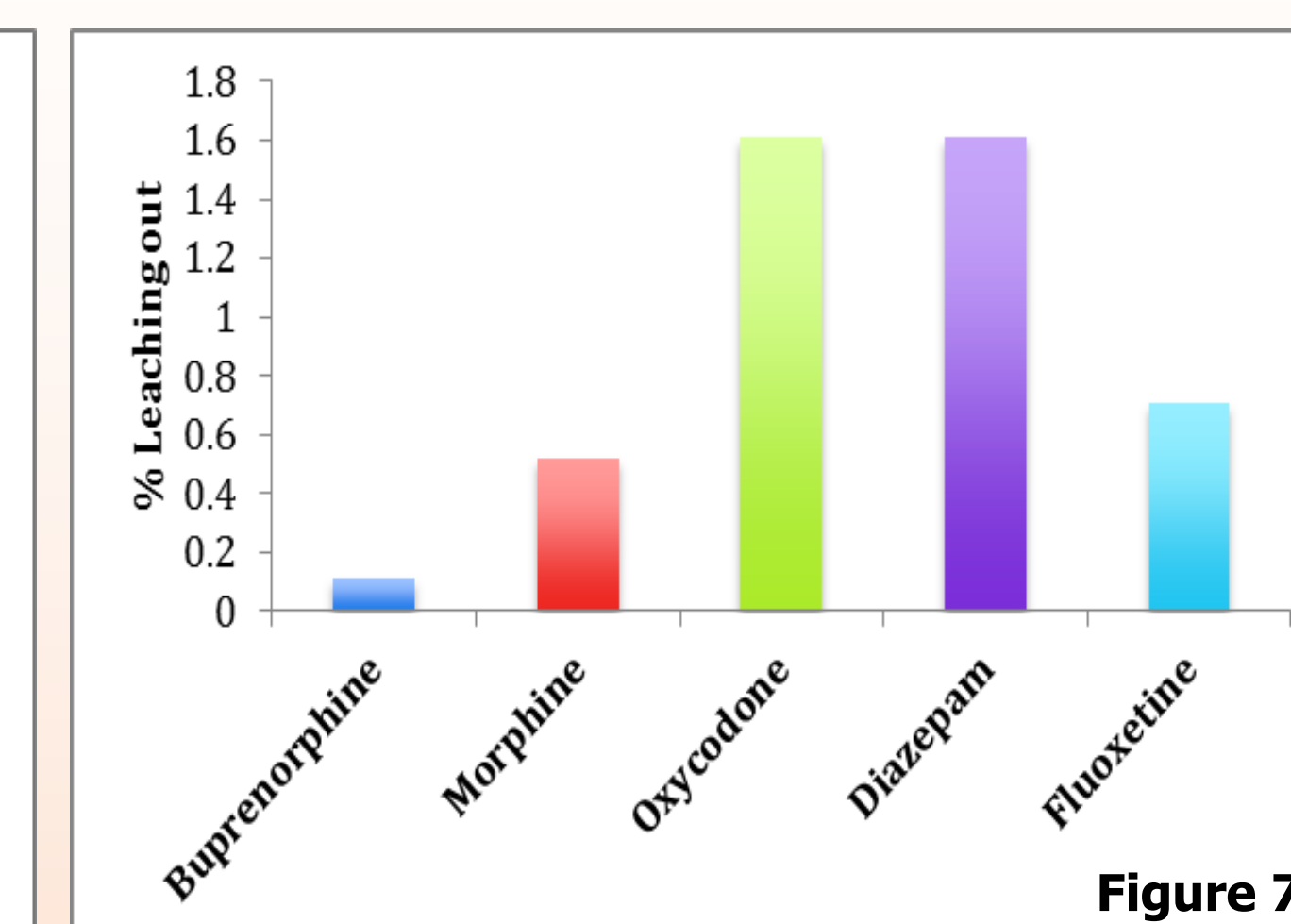


Figure 7: Desorption study of oxycodone, morphine, buprenorphine, diazepam and fluoxetine in 30% ethanol

CONCLUSION

The efficiency of the activated carbon based drug disposal system was examined on five model psychoactive medications. The deactivation pouch successfully adsorbed psychoactive medications within 28 days and did not release adsorbed drug substances when exposed to large volumes of water and ethanol. Thus, the activated carbon based system offers a simple, safe and effective procedure for patients who can deactivate these unused medications from the comfort of their homes.

Acknowledgment:

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Reference

1. Herwadkar A, Singh N, Anderson C, Korey A, Fowler W, Banga AK. Development of disposal systems for deactivation of unused/residual/expired medications. Pharm Res. 2015 Aug 12. [Epub ahead of print]