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Research pedagogy

KAZA'S Carbons- Tools of Defluoridation of Drinking (Potable) Water

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ABSTRACT

*Commercially available **a**ctivated Carbon is used in medicine, dyeing industry, pharmaceutical industry and as adsorbent in industrial sector. The cost depends upon purity, quality and physical form. Our group started intensive studies on Palmyra male Inflorescence (which is waste from Palmyra tree in fields) with a focus around GIGO (Garbage [or bio-waste] in gold out) philosophy and practices of biotechnologists With the progressive extensive utility in diverse application areas, this group of materials have become popular as **KAZA'S Carbons (KAZACs).** . This type of Carbon first time I had prepared, i.e**., I had Invented and Named in the Name of Me, these Carbons that are prepared hereafter were as KAZA'S Carbons**. Critical fluoride content and fluorosis effect on Human Health presented. Lab. Method and Large Scale (House hold) Method for removal of fluoride in drinking water using KAZA's Carbons were discussed.*

Keywords: Preparation of KAZA's Carbons, Effect of Fluoride, Removal Methods.

INTRODUCTION

Commercially available **a**ctivated Carbon is used in medicine, dyeing industry, pharmaceutical industry and as adsorbent in industrial sector. The cost depends upon purity, quality and physical form. Our group started intensive studies on Palmyra male Inflorescence (which is waste from Palmyra tree in fields) with a focus around GIGO (Garbage [or bio-waste] in gold out) philosophy and practices of biotechnologists With the progressive extensive utility in diverse application areas, this group of materials have become popular as **Kaza'S Carbons (Kaza_Cs).**This type of Carbon first time I had prepared, i.e**., I had Invented and Named in the Name of Me, these Carbons that are prepared hereafter were as KAZA'S Carbons[1,2].**

Experimental design of preparation of Kaza's carbons

Preparation: The different Bio-waste materials viz. Mango shells, Maize shells, Citrus peels, Dalicus lab were collected. They were crushed into small pieces, washed with water and dried under sunlight for three days. The dried material was carbonized in N_2 atmosphere at 100^o-500^oC. The rate of heating was

maintained at $10^{o}C\ min^{-1}$ in a muffle furnace. It is then cooled to ambient temperature, ground and sieved with 45 mesh. Over years, more than 20 KAZA's Carbons were prepared and tested chart 1.

Chart 1: Abbreviations and sources of Kaza's carbons

S.No.	Botanical name	Symbol given
1	Ficus benghalensis	**FBC**
2	Phaseolus mungo	**PMC**
3	Citrus nobilis	**CNC**
4	Diascoria sps	**DCC**
5	Amorphophalus	**AMC**
6	Colocasia esculenta	**CCC**
7	Manihot utilsmus	**MUCV**
8	Bombax malabaricum	**BMC**
9	Pithacelobium dulce	**PLDC**
10	Ipomoea batatas	**IBC**
11	Peltophorum ferrugineum	**PFC**
12	Enterlobium Saman	**ESC**
13	Acacia arabica	**AAC**
14	Prosopis juliflora	**TJC**
15	Citrus limon	**CLC**
16	Borassus Flabelliformis (inflorescences)	**PMIC**
17	Borassus Flabelliformis (endocarps)	**PEC**
18	Mangnifere indica	**MGSC**
19	Zia Maize	**MZSC**
20	Dolichos lablab	**NDLC**
21	Brassica Juncea	**NBSC**
22	Cajanus Cajan	**NCCC**
23	Typha angusta	**NTAC**

Activation: Activation of carbons for the application in defluoridation process is done with dilute acids. Especially in case of KAZA's Carbons, 1M nitric acid was used. This treatment renders to increase O^{-} functional groups on the surface of carbon.

Unit operations for activation:

- Add raw carbon to a beaker containing 1M HNO_3
- Stir well, keep aside (1-2h) for soaking and settle
- Remove the supernatant liquid
- Wash carbon with redistilled water many times → gets acid free carbon
- Dry in air and sunlight

Characterisation: EDAX is used to assess contaminants as the source material for preparation of carbons in bio-waste. The other techniques employed are FTIR, XRD, surface area analysis and SEM. The physico-chemical characteristics viz. pH, moisture content, ash content, apparent Density, volatile matter, acid and water solubilities are described in Table 1

Table1. Physical characteristics of KAZA'S Carbons

S.No.	Properties	FBC	PMC	CNC	DCC	AMC	CCC	MUC	BMC	PLDC	IBC
1	pH	7.11	7.26	7.5	6.48	6.47	6.38	7.62	7.84	7.35	7.21
2	EC(µs)	78	75	103	25	28	21	26	65	58	48
3	pH_{zpc}	7.95	7.78	7.6	6.96	6.78	6.98	7.02	7.3	7.5	7.1
4	LOI	98.25	97	90	93.05	94.98	96.89	81.86	89.78	94.5	96.79
5	Mechanical Moisture(%)	0.09	0.12	0.21	6.6	3.82	4.9	4.9	6.33	3.53	7.2
6	Apparrant density(g/ml)	0.73	0.42	0.22	0.35	0.292	0.454	0.4534	0.2779	0.4348	0.313
7	Water soluble matter(%)	0.33	0.42	0.7	0.81	0.09	0.15	0.81	1.83	2.02	1.09
8	Acid soluble matter(%)	3.5	4.8	11	1.25	2.38	1.63	3.7	1.47	1.69	1.47
9	Surface area(Å)	9705	9806	9410	10860	9986	9856	9506	9918	9587	8625
10	Decolourizing power(mg/g)	14.5	13	11	112	108.5	12	127.2	87	91	98.2

Continued----

#	Porperties	PFC	ESC	AAC	PJC	CLC	PMIC	PEC	MGSC	MZSC	NDLC	NBSC	NCCC	NTAC
1	pH	7.7	7.64	7.27	7.16	7.6	7.26	7.11	7.5	7.39	7.21	7.14	7.36	7.05
2	EC(µs)	61	133	129	87	102	75	78	103	89	93	84	98	76
3	pH_{zpc}	7.09	7.5	7.12	7.3	7.6	7.65	7.58	7.95	7.82	7.60	7.61	7.94	7.85

4	LOI	99.8	98.0	90.6	99.78	98.62	98.25	98	90.5	95	98.00	98.25	90.50	95.00
5	Mechanical Moisture(%)	6.47	0.48	0.045	0.074	0.087	0.047	0.602	0.053	0.04	0.402	0.028	0.033	0.021
6	Apparrant density(g/ml)	0.26	0.55	0.496	0.23	0.144	0.681	0.759	0.532	0.584	0.624	0.418	0.571	0.345
7	Water soluble matter(%)	2.15	0.52	0.34	0.13	0.15	0.22	0.33	0.8	0.58	0.33	0.12	0.73	0.16
8	Acid soluble matter(%)	1.67	3	1.04	3	4.14	3.5	9	11	11.68	6.3	2.86	15.78	2.48
9	Surface area(Å)	8615	9439	9524	9047	8058	9518	8871	7470	8500	140.4 m^2/g	106.2 m^2/g	77.7 m^2/g	32.46 m^2/g
10	Decolourizing power(mg/g)	101	99	101	95	89	below 15	below 15	Below 15	Below 15	below 15	below 15	Below 15	Below 15

APPLICATIONS

These Kaza's carbons have been used as adsorbents for different purposes. The adsorption is surface phenomena i.e. ions are attracted on to the surface of carbon. To improve efficiency of the carbon there are many processes like activation, impregnation, conversion to graphite or nano-materials etc.

In these processes surface area increases and small amounts of carbon is sufficient. The activated KAZA's Carbons are powerful agents in removing fluoride contaminated drinking water. Appendix 1 briefly documents with fluoride associated human health risk and international/national drinking water standards.

Removal of fluoride (Defluoridation) in Drinking Water by Activated KAZA'S Carbons: A plethora of protocols for defluoridation are available in literature. A few typical ones include adsorption, ion-exchange- Defluoron-1, precipitation methods viz. lime and alum, poly aluminium chloride (PAC), gypsum and fluorite filter, granulated bone media and bone char, activated alumina –activated bauxite method, ion exchange resins, Waso resin and defluoron-2, electrochemical coagulation, reverse osmosis and electro dialysis method. We applied activated KAZA'S Carbons successfully for this purpose (chart 3). The filtered carbon can be used for 4 -5 times depending on its ability in removal of fluoride. The activated carbon can also be regenerated by treating with dilute sodium hydroxide solution.

Unit operations of Kaza's Carbon Method

- Optimum amount of activated carbon (KAZA'S Carbon) prepared from bio-waste added to a beaker
- Spiked with 5mg L^{-1} of fluoride and pH maintained
- Stir solution → contact developed for fluoride water with carbon
- Keep the system for 30min -1h to settle carbon
- Filter out water
- Determine the fluoride content

The results of maximum % removal of fluoride by KAZA'S Carbons are presented in table 2.

Table 2: Efficiency of Kaza's carbons in fluoride removal

S.No.	Shortcut Name of Carbon	Optimum adsorbent dose (g L^{-1})	Optimum contact time (min)	Optimum Initial Conc.of F^{-1} (mg L^{-1})	Optimum pH	Maximum percent removal
1	FBC	5	25	5	7	77.6
2	PMC	5	25	5	7	73.8
3	CNC	5	25	5	7	68
4	DCC	3	40	5	7	83.8
5	AMC	3	40	5	7	81.2
6	CCC	3.5	40	5	7	77.2
7	MUC	3.5	40	5	7	72.6
8	BMC	3	40	5	7	80
9	PLDC	3	40	5	7	76.6
10	IBC	3	40	5	7	73.7
11	PFC	3.5	40	5	7	83.7
12	ESC	3	40	5	7	80
13	AAC	3	40	5	7	76
14	PJC	3	40	5	7	85.2
15	CLC	3.5	40	5	7	82.3
16	PMIC	3	30	5	7	77.2
17	PEC	3	30	5	7	74.2
18	MGSC	3	30	5	7	68.4
19	MZSC	3	30	5	7	52.8
20	CAC	3	40	5	7	35.8

The results indicate that optimum concentration of carbon and maximum percentage of fluoride removal varies from one carbon to other carbon. Any KAZA's Carbon has good efficiency when compared to commercial activated carbon (CAC) as evident from table 3. We applied this method for real life samples also where fluoride content is >1.5 mg L^{-1} in drinking water. For example in Reddigudem Mandal, Krishna Dt. A.P., before defluoridation, the F^- content in ground water was (earlier Work) - 0.48 to 2.56 mg L^{-1} (bore well); 0.41 to 3.20 mg L^{-1} (hand pump); 0.01 to 2.88 mg L^{-1}.(open well). After affecting defluoridation using our method F^- in water is 0.76 to 1.21 mg L^{-1}(bore well); 1.35 to 1.45 mg L^{-1} (hand pump); 0.92 to 1.18 mg L^{-1} (open well). Similarly in A. Kondur Mandal, Krishna Dt. A.P., Bore well water before defluoridation was found to be 3.06 and after treatment it drastically reduced to 1.31; Hand pump water 2.70 to 1.08; Open well water from 2.32 to 1.29. We have extended this approach to affected areas in Nalgonda Dt. (presently Telengana State).

Large Scale and House-hold (Inexpensive) Method: This present method is implementable with ease even in houses in areas where water is contaminated with fluoride. Either raw carbon prepared as above or activated carbon added in sufficient amount in big pot of fluoridated water. After stirring well, it is kept overnight undisturbed to settle. In the morning filter the water (now with reduced fluoride) and use for drinking purposes. These Carbons are non-poisonous and available in plenty.

Appendix 1: Fluoride in Drinking Water

Fluoride enters in human body mainly through drinking water and indiscriminate use of fluorinated tooth pastes, mouth washes etc. Approximately 90% of fluoride is retained in the body and deposited on skeleton and teeth. Fig.1 shows sources of fluorine and fluoride are from fluores and fluorspars. The presence of excess F^- in water causes fluorosis, a dangerous decease spread Worldwide (Fig. 2). WHO stipulated maximum permissible limits for fluoride (chart 2) and excess amounts vitiate human health.

Fig 1. Fluores and Fluospars

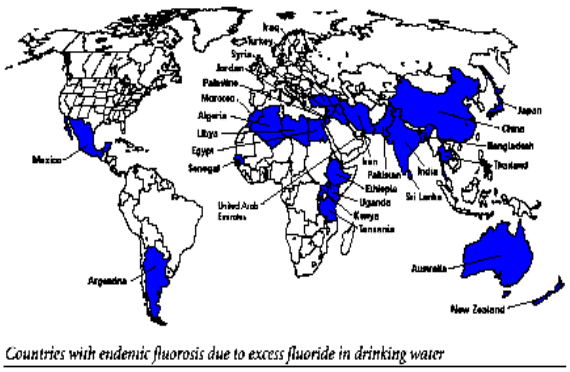

Fig 2. Spread of fluorosis countrywise

Chart 2: Permissible limits of fluoride				
Warm Climate	below 1mg L^{-1}			Country specific limits
Cooler Climate	upto 1. 2 mg L^{-1}			India 1.5 to 1.0 mg L^{-1} (1998)
Normal conditions	1.5 mg L^{-1}			China 1.0 to 0.5 mg L^{-1} (1975)
				USA 2.4 to 1.4 mg L^{-1} (1975)

Air: Air (Maximum Permissible Limits Who Limits) - Natural background Concentrations are 0.5ng $m^{3\,-1}$ (permitted value). WHO analyzed concentrations in some countries - USA and Canada 0.02 to 2.0 µg $m^{3\,-1}$, China and India 16 to 46 µg $m^{3\,-1}$, Netherlands 30 to 40 ng $m^{3\,-1}$.

Soil: There are no legal limits for fluoride content in soils but 400 mg kg^{-1} is regarded as the "investigation level". Only minute amounts of fluoride are taken up by plants. Applied fluoride does not migrate through the soil or leach into waterways i.e. it will accumulate in the soil, particularly the upper 30 cm. Single Superphosphate contains about 15,000mg fluoride kg^{-1} SSP*, RPR contains about 30,000mg fluoride kg^{-1} RPR* (*Variations depend on source of material). Fluoride accumulates in the soil at a rate of about 5-10% per year. Accumulation rate depends on the type of fertilizer and rate of application. Applied fluoride (via fertilizer) is not a threat to human health, but there is a risk to grazing animals.

Effect of Fluoride on human health: The multiple ill effects of ingestion of fluoride beyond toxic limits have several manifestations. Some of the severe diseases affecting even normal course of life include neurological, muscular, gastro-intestinal, urinary tract disorders. The severity of symptoms if F^- above 1.5 mg L^{-1} is in figures 3-6. If fluoride is less than 0.5 mg L^{-1} the symptoms are shown in figs 7- 9.

Fig 3a. Fluores and Fluospars

Fig 3b. Crippling Skeletal Fluorosis in India

Fig 4. Fluoride effected Spinal card

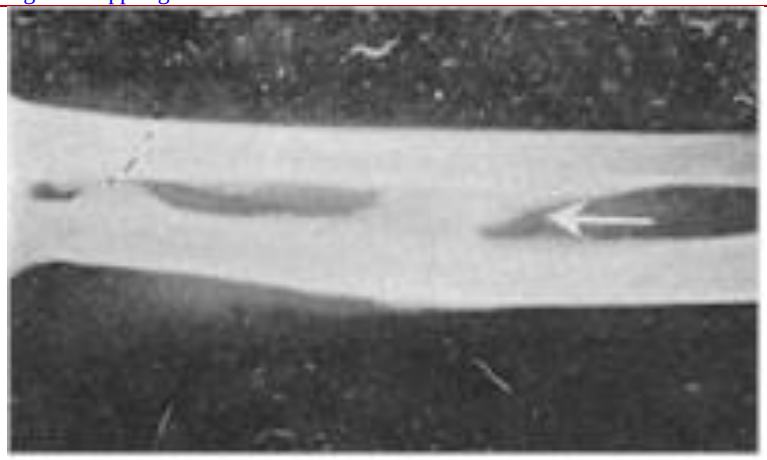

Fig 5. Fluoride Effected Bone

Fig 6. Fluoride Effected Legs

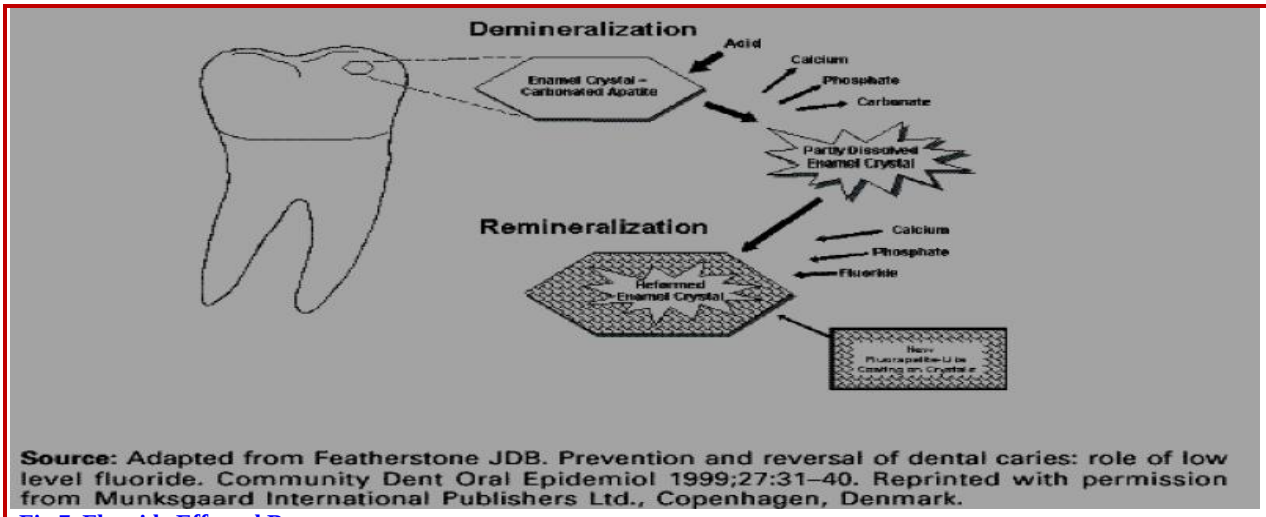

Fig 7. Fluoride Effected Bone

Fig 8. Initial stages of F^- effect on Teeth

Fig 9. Severe Effect of fluoride on Teeth

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