

Researches On Resources Of SINDH

by

Dr. P. Habibullah



SINDHI ADABI BOARD
JAMSHORO, SINDH

RESEARCHES ON RESOURCES OF SINDH

By

DR. P. HABIBULLAH Ph.D.



SINDHI ADABI BOARD
Jamshoro, Sindh

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Publisher's Note

The Province of Sindh is not only famous universally for its ancient Indus Civilization, but also for its gorgeous resources. In the past few years, Dr. Parvaiz Habibullah has conducted some work on some of the most lucrative resources of Sindh and has published his researches in renowned scientific and research journals of international repute. Sindhi Adabi Board being an organization which is trying to promote the rich heritage of Sindh, has decided to republish these diversified researches in the form of a single collection under the title "Researches on Resources of Sindh."

RESOURCES	TITLE OF RESEARCH WORK
Water	Heavy metals in Sindh waters.
Wind	Wind tube - Design & fabrication.
Ocean	Researches on marshes on Rann-of-Kutch.
Solar	Solar Energy in powder metallurgy.
Land	Chemical, mineralogical & bacterial analysis of Bholari Sands.
Ancient Civilization	Casting techniques of coins of ancient Indus Civilization of Bhanbhore. Metallurgy of ancient Civilization of Mohen-jo-daro.

Originally this collection of papers is meant for researchers working on the related topics, because it acquaints the reader with most recent information but at the same time, it will also prove informative for general masses.

Jamshoro, Sindh
2nd December, 1995.

Murad Ali Mirza
Secretary
Sindhi Adabi Board,
Jamshoro.

FOREWORD

After completing my Ph.D in Engineering from Romania, in 1986, I was selected as the chief of Electro-Mechanical Engineering School of Civil Aviation Training Institute, Hyderabad, Sindh. From very beginning of my service at Hyderabad, I was eager to carry out some meaningful and valuable researches on resources of Sindh, by Utilizing my own resources and some assistance from the eminent Professors of all the three Universities, namely, Sindh University; Mehran University of Engineering & Technology Jamshoro, Agriculture University, Tandojam and researchers from the research Institutions e.g. Atomic Energy Agriculture Research Centre, Tandojam, Atomic Energy Medical Centre, Jamshoro, Pakistan Council of Scientific and Industrial Research Renewable Energy Centre, Hyderabad, T & T Workshop Kotri, Zeal Pak Cement Factory, Hyderabad and some other renowned institutions of the Country. In past 7 years, I have completed some work on Solar Energy, Wind Energy, Marshes of Rann of Kutch, Indus River water and Bholari Sands. In Cultural heritage of Sindh, I have also conducted some studies on Brass and Bronze antiques of Mohen-jo-daro and Metallic coins of Bhanbhore. In elaborating articles on all these topics, I have always tried to carry out research on the new phases of these topics. Out of collection of 7 articles, 5 have already published in Scientific Journals of International repute.

Hyderabad
Aug 5, 1995

Dr. P. Habibullah
Chief EME School,
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SINDHI ADABI BOARD JAMSHORO

RESEARCHES ON RESOURCES OF SINDH

Dedicated to renowned Geographer and my esteemed friend late Professor Sher Ahmad Khan, who is the co-author in some of the research papers included in this book and who died on 6th October 1995, before publishing of this book.

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RESEARCHES ON CHEMICAL, MINERALOGICAL AND BACTERIAL ANALYSIS OF BHOLARI SAND

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RESEARCHES ON CHEMICAL, MINERALOGICAL & BACTERIAL ANALYSIS OF BHOLARI SAND.

KEY WORDS:

General - Molding Sand: Properties, ingredients - Researches on Bholari Sand: Analysis, properties, Bacterial Hazards of Sand & its mixture with mollasses - Conclusion, Bibliography.

ABSTRACT:

Bholari is a small village situated near Kotri, District Dadu in the Province of Sindh, Pakistan. It contains huge deposits of (SiO₂) sand which are extensively utilized in sand molding, both for ferrous and non-ferrous castings (specially it is used at T & T Foundry, Kotri). Earlier no proper work was carried out on molding properties of Bholari Sand. Authors have collected its samples from the site and have studied its molding properties, analysis and bacterial hazards, both, alone and with its mixture with molasses, a common binder of molding sands. It is concluded that although, this sand cannot be recommended as natural bonded sand, because it contains very small amount of clay (<0.5%), but it can be used as molding material after addition of 5-8% clay, 1.5% water and adequate quantity of additives e.g. molasses. The Bacteriaculture investigations carried out at Vet. Research Institute, Lahore shows that Foundrymen working with this sand will remain free from any bacterial hazard.

INTRODUCTION

Bholari is a small village of Kotri, which is situated near Hyderabad, Sindh at the right bank of river Indus. It is particularly famous for its sand dunes, which have been commercially utilized for molding, casting, construction

purposes and making glass bangles. Now investigations are being carried by the Zeal Pak. Cement Factory, Hyderabad for its utilization in the manufacturing of cement.

After the announcement by the Ministry of Defence, Pakistan in the news media in 1990 that one of the biggest and most modern Airbase of PAF will be built at Bholari, the importance of this Village has increased tremendously.

2. EXPERIMENTAL.

2.1. ANALYSIS.

2.11. CHEMICAL

Samples of sand were analysed in Zeal Pak. Cement Factory, Hyderabad. As per results, it contains $\text{SiO}_2 = 82.70\%$, $\text{Al}_2\text{O}_3 = 1.86\%$, $\text{Fe}_2\text{O}_3 = 0.07\%$, Lime = 7.55% , $\text{MgO} = 0.29\%$ and $\text{SO}_3 = \text{traces}$. Table 1 gives the analysis of Bholari sand and its comparison with other types of SiO_2 based molding sands.

2.12. Sand Grains

Sand grains are generally of different shapes e.g. round angular & subangular and compounded. (Macrographic studies photo 1).

2.13. Minerals in SiO_2 Sand:

Some of the minerals present in SiO_2 sand are given in table 2.

2.14. Sand Grains

Clay minerals present in silica (SiO_2) sand are given in tabel 3 [2]. Their photo micro structures at very high magnification are given in photo 2 (a to c).

BHOLARI SAND DUNES



Table 1 : Chemical composition of typical sands and its comparison with Bholari Sand.

Constituents	Washed silica sand *	Washed & dried silica+	Typical band sand + +	Bholari Sand	Western bentonite bonded silica sands §		Typical lake sand
					New	Used	
loss on ignition, % .....	.....	.....	1.02	5.86	0.28	0.12	0.80
C, %	.....	.....	.....	.....	0.13	0.59	.....
Free iron, %	.....	.....	.....	.....	.....	0.97	.....
Ferrous iron, %	.....	.....	.....	.....	0.44	0.68	.....
Ferric iron, %	.....	.....	.....	.....	0.00	0.12	.....
Total iron, %	0.10	.....	.....	.....	0.44	1.77	.....
Al ₂ O ₃ %	0.39	.....	.....	1.86	1.32	0.63	.....
SiO ₂ %	99.08	99.80+	92.09	82.70	95.79	95.54	95.0+
Total Al ₂ O ₃ +Fe ₂ O ₃ %	.....	.....	6.09	2.56	.....	.....	2.0
CaO, %	.....	.....	0.58	7.55	.....	.....	0.60
Alkali, %	.....	.....	0.22	.....	.....	.....	0.20
MgO, %	.....	.....	0.22	0.29	.....	.....	0.40
SO ₃	.....	.....	.....	Traces	.....	.....	.....

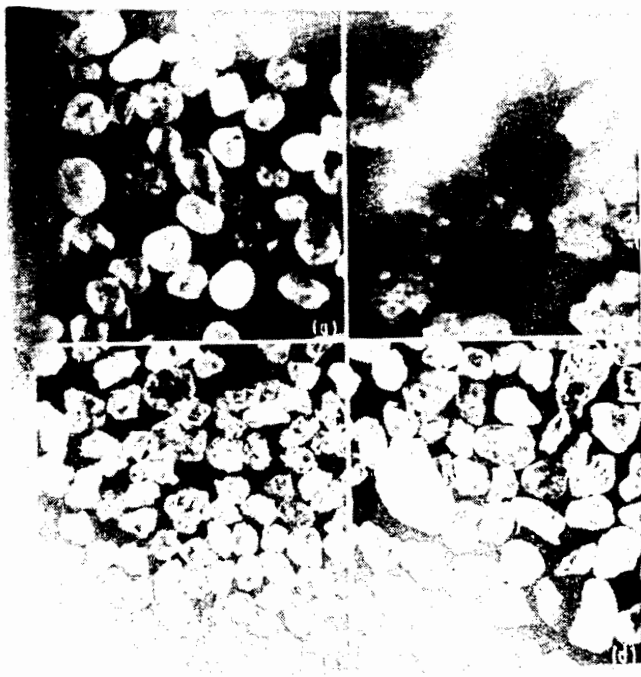
* New Jersey Silica Sand Co.

+ Ottawa silica sand.

++ Great Lakes Sand Co., Juniata.

§ A molding sand from F. L. Orell, Jr., "The constitution of Discarded Molding Sand, Steel Founders Society of America Report 23, 1950.

MACROGRAPHIC PHOTO 1.



Sand grains shapes. (a) Rounded sand grains, (b) angular sand grains, (c) compounded sand grains, (d) subangular sand grains (From AFS)

TABLE 2**SOME OF THE COMMON MINERALS PRESENT
IN SILICA SAND**

Mineral	Chemical Formula
Mica Muscovit	$K_2O3H_2O.6SiO_2 \times 2H_2O$
Magnesium carbonate	$MgCO_3. 3H_2O$
Calcite	$CaCO_3$
Dolomite	$CaCO_3.MgCO_3$
Siderite	$FeCO_3$
Glauconite	$K_2Mg (Fe, Al) 3SiO_4$ $\times 3H_2O$
Iron Ore (Hydrate)	$nFe_2O_3.mH_2O$
Aluminium hydrates	$nAl_2O_3. mH_2O$

Table 3 : Clay minerals used for bonding molding sands*

Clay mineral type	Composition type	Base exchange	Refractoriness (softening point)	Swelling due to water	Shrinkage due to loss of water	Particle size and shape
Montmorillonite class IA, western bentonite Source: Wyoming, south Dakota, Utah	$(\text{CH})_4\text{Al}_4\text{Si}_8\text{O}_{20}\text{nH}_2\text{O}$ Ex: 90% montmorillonite, 10% quartz, feldspar, mica etc.	High. Na is adsorbed ion, PH = 8-10	2100-2450 F	Very high, gel-forming	Very high	Flake size of less than 0.00001 in.
Montmorillonite class IB, southern bentonite	$(\text{CH})_4\text{Al}_4\text{Si}_8\text{O}_{20}\text{nH}_2\text{O}$ Ex: 85% montmorillonite, 15% quartz, limonite, etc.	High. Ca is adsorbed ion, Ph = 4-6.50	1800 F+	Slight tendency to gel.	Very high	Flake size of less than 0.00001 in.
Kaolinite class IV, fire clay source: Illinois Chio	$(\text{CH})_4\text{Al}_4\text{Si}_4\text{O}_{10}$ Ex: 60% kaolinite, 30% illite, quartz, etc.	Very low	3000-3100 F	Very low, non-gel-forming	Low	Fire clays are often ground and therefore may be relatively coarse or may be ground to a flour
Illite Class III, grundleite	$(\text{CH})_4\text{K}(\text{Al}_4\text{Fe}_4\text{Mg}_4\text{O}_{20})$	Moderate	2500 F±	Low, non-gel-forming		

* Adapted from R. E. Grim and F. L. Cuthbert.

OTHER SILICA DEPOSITS OF HYDERABAD DIVISION [3,4]

The silica sand deposits ($25^{\circ} 09' 30''$ N : $68^{\circ} 07' 30''$ E) of Dadu District occur in the rocks of Eocene age and fall in topographic sheet 40 C/4 exposed in low hills between meting and Jhimpir Railway stations. The deposits are approachable also from the Hyderabad Thatta Road. The thickness of the bed varies from one and a half to 20 feet.

The Jangshahi silica sand deposits are located to the east and north of the Jangshahi Railway station. There are three prominent deposits (1) near the 4-mile milestone on Jangshahi Thatta road; (2) at five miles to the north-northeast of Jangshahi and at one and a half mile to the east of Sindar. The deposits are lenticular in nature. Reserves of both good and poor quality sand for the above three deposits have been estimated as follows:-

(1) 20,000 tons of good quality and 50,000 tons of poor quality.

(2) 5,000 tons of good quality and 20,000 tons of poor quality.

(3) 40,000 tons of good quality and 100,000 of poor quality.

The Thana Shah Beg silica sand deposits is located at about 30 miles to the west-northwest of Thano Bula Khan. The white sandstone occurs in patches capping one of the hillock in that area. The rocks belong to Oligocene age. Reserves of all categories have been estimated at 300,000 tons.

The Unt Palan silica sand deposit ($25^{\circ} 13' N$: $67^{\circ} 37' E$) is located near Unt Palan in Dadu District. The deposit is 15 to 30 feet thick and extends over a considerable distance. Reserves of all categories have been estimated at 3,000,000 tons.

Kaolin deposits occur in the Nagar Parker peninsula, near Didwa, Prodhora and Dhed Vero Villages.

The Kaolin deposits are lenticular in shape, ranging in thickness from a few inches to about 10 feet. The quality of the clays varies both laterally and vertically. Reserves in all categories exceed 150,000 tons. Transporting this clay across 120 miles to desert to the nearest railway station at Naukot may present some difficulty.

Analysis of soil samples collected from 50,000 acres of Deh Akro and Chak-9 situated in Taluka Nawabshah consisting of mostly sand dunes, is as under [4]:-

Nature	=	Saline
Ec	=	0.08 to 2.14 dSm-1
pH	=	8.1 to 9.1
Texture	=	Loose
Size	=	Fine to Coarse

MICRO PHOTO NO. 2

KAOLINITE

30000X



MONTMORILLONITE

38000X



ILLITE

45000X



2.2 BACTERIAL HAZARDS

The atmosphere of foundries is not free from pollution. Most of the researchants have conducted their investigations on pollution created by gases and SiO₂ dust evolved during moulding, melting, casting and fettling. Noise (dB) pollution is also higher than the admissible limits. This has also been investigated extensively by the foundrymen. However, bacterial hazards found in the atmosphere of foundry have not been taken seriously and these pollutants are not investigated meticulously. Authors have collected samples from the Bholari site and have cultured them in different media e.g. Nutrient Agar (NA), Macconkey Agar (MA), Selerod Agar (SA) and Nutrient Broth (NB) and similarly, the molasses, which is extensively used both in ferrous and non-ferrous foundries, as an additive for developing better binding strength of moulding sand, were cultured. In foundries, specially in small foundries, sand, clay and mollasses are mixed by hands. If some moulder having a cut in his hand, mixes these ingrediants, he may be affected by bacteria of sand, clay, mollasses or other addivites e.g. horse dung etc. Keeping in view, the seriousness of this phenomenon, authors have studied the bacterial hazards of Bholari sand.

2.21 PROCEDURE FOR INDENTIFICATION OF MICRO ORGANISMS

The details of technique for the staining process is as follows:-

1. Stain the film 2 minutes with Hucker's gentin violet prepared as follows:-
 1 ml. saturated alcoholic solution, gentin violet or crystal violet (4 grams dye in 20 ml of 95% ethyl alcohol).
 10 ml. of 1% ammonium oxalate.
2. Wash with water and apply Gram's iodine 1 minute. Gram's iodine is prepared as follows:

Iodine	1 gm.
Potassium iodide	2 gms.
Distilled water	300 ml.

3. Pour off excess fluid and wash with acetone (10 parts) and 95% alcohol (70 parts) until the smerceases to lose color.
4. Wash with water.
5. Counter stain with 2% aquaous solution of ranin.
6. Wash with water, blot dry and examin.e

RESULTS

The results of culturing sand and molasses are given in table 4. It is concluded that sample of both of these materials are free from bacterial hazards.

TABLE 4
CULTURAL REPORT OF MOL-ASSESS & SAND

DATE	CULTURE	Seen on 26-4-93
25-4-93	Culture of Molasses on N.A. (Nutrient Agar)	3 big colonies seen, opaque & yellow coloured
-do-	Culture of Molasses on M.A. (Maconkey Agar)	Sterile (no growth)
-do-	Culture of Molasses on S.A. (Selerod Agar)	Heavy Fungus growth seen.
-do-	Culture of Molassess on N.B (Nutrient Broth)	Heavy turbidity was seen.
25-4-93	Culture of Sand on N.A.	Two type of colonies seen, big & small opaque coloured.
-do-	Culture of Sand on M.A.	Sterile.

-do-	Culture of Sand on S.A.	Sterile.
-do-	Culture of Sand on N.B.	Little Turbidity seen.
	RECULTURE	SEEN ON 27-4-93
26-4-93	Reculture on S.A. from N.B. of Sand Reculture on S.A. from N.B. of Molasses	Sterile. Fungus isolated.
27-4-93	Morphological report of Sand.	Organisms were given negative cocci tested form observed, not dangerous for human health.
28-4-93	T. B. report of Sand.	Negative

3. CONCLUSION

Summing up the investigations on Bholari Sand, it can be concluded that:-

1. Although analysis of Bholari sand have shown that it contains very little quality of clay, but it can be used for casting different ferrous & non-ferrous alloys by making its mixture with an adequate quantity of clay bentonite and other additives. Table 5 summaries the different types of sand mixtures which can be used for casting different ferrous & non-ferrous alloys.

2. Bholari Sand is free from any bacterial hazards. In small foundries, the foundry men mix the sand with other ingredients and additives e.g. molasses, by mulling with hands. Cultural reports of molasses of Bholari sand have shown that in cultured samples small, opaque or yellow colonies have appeared, but they were considered to be harmless and sand was declared free from any bacterial hazards for use in foundries.

3. However, like any other SiO_2 sand, Bholari sand is strong source of Silicosis. Substitution of non-silica moulding aggregates e.g. olivine, zircon or chromite sand, for silica in

Table 5 : Example of sand mixtures

Sand Type	Sand green base	clay binder	other additives	comments
Steel general facing.	Silica sand, 40-60 AFS fineness	7% western bentonite	14% silica flour, mollasses water	Temper heavy with water and use sufficient dextrin or mollasses, bake at 600 F until dry
Steel,	50% new silica sand, 40-60 AFS fineness, 50% reclaimed system sand.	7-8% fire clay, 1-2 % western bentonite	2-3% silica flour	Temper heavy with water bake at 650 F until dry.
Gray iron, general	40% new silica, 50-60 AFS, 60% old sand of same source	3-6% western bentonite	1.0-20% pitch 1.0-1.5% cereal	Temper to good workable moisture. Typical sand properties: 8.0-10 psi green strength, 90-120 per meability, 4-5% moisture. Bake at 350-450 F.
Steel, air-dry	New or reclaimed silica sand, fineness 40-60 AFS.	3.5% western bentonite	5% silica flour, 1.25% cereal.	3.5-4 % moisture air-dry open mold.

moulding material can reduce SiO_2 control by 80%, because respirable particles are reduced greatly when olivine sand is used. It imparts greater resistance to thermal shock to casting. Its low thermal expansion can minimize the need of organic additives. The ratio of forsterite to fayalite is properly controlled, because it determines the amount of mineralogical impurities olivine does not create silicosis.

4. **ACKNOWLEDGEMENT**

Authors are highly grateful to Mr. Tasawar Rao, Chemist, Zeal Pak Cement factory, Hyderabad for conducting the chemical analysis of Bholari sand.

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CASTING TECHNIQUES OF COINS OF
ANCIENT INDUS CIVILIZATION OF
BHANBHORE

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* *Summary of paper was accepted for this conference.*

CASTING TECHNIQUES OF COINS OF ANCIENT INDUS CIVILIZATION OF BANBHORE

SUMMARY

BANBHORE-SHAH LATIF's IMMORTALIZED CITY OF LOVE

The ruined city of Banbhore is situated on the right bank of Gharo creek, about 60 km, south east of Karachi and 4 km from National Highway. Excavations carried out there, since 1958, by the Department of Archaeology and museums. Government of Pakistan have revealed that the remains of an ancient town are divided in two parts, the fortified citadel area of the mound itself, measuring about 2,000 ft by 1,000 ft. and the lower city round the lake on the foot of the mound, extending outside, which includes an industrial area.

Preliminary studies of the better preserved and decipherable coins have yielded significant informations. Among them the following important coins deserve a special mention.

Pre-Islamic Coins

Among them, the best preserved specimen represent an Arab-Sassanian coin bearing, on the obverse, the bust of a typical Sassanian coin and a short legend in Pahlevi, and on the reverse, a fire alter, mint name, and date in Yezdgird era. The mint name has been read as Mary and the date as 21 Y.E (Yajvist) i.e. 32 A.H/652 A.C.

Two partially preserved Indo-Sassanian silver coins are interesting in their present decayed condition that they are without any legend. This type of coin is commonly known as Gadlhaiya, probably because the distorted relief of the facial profile gives roughly the appearance of an ass. Its origin is attributed to the legendary Vikramaditya of Ujjain (441 A.C). Its period of currency in Gujrat and Rajputana is stated to be from about 570 A.C to 1100A.C.

A copper coin with a squat ing bull on one side and two fish motifs facing opposite directions on the other. Similar coins have been recovered from the ruins of the ancient city of Montolle in Ceylon. Its date is not known.

Islamic Coins

They include more than a hundred copper and two dozens of silver coins, and also a gold coin in a very good state of preservation. It belongs to the ninth Abbasid Caliph Abu Jaffar Haroon-al-Wasiq Billah who ruled in Bughdad from 227 A.H to 232 A.H (842 A.C to 847 A.C). It was minted in Egypt in 229 A.H (843 A.C). This coin was discovered on the lime-plastered floor of a burnt brick house in the northern part of the citadel.

IRON ANTIQUE FROM BANBHORE

CHEMICAL ANALYSIS

Carbon C%	1.530
Sulphur S%	0.012
Manganese Mn%	Nil (0.001) ?
Si	0.360
Phosphorus P%	0.011
Chromium Cr%	Nil

OTHER METALLIC ANTIQUES

- Baked honey comb clay slabs mostly in fragments, in citadel area, in upper level vitrified under heat, small copper and silver coins.

- Copper and Bronze objects large variety of copper and bronze spoons, Antimony rods, Antimony tools, bangles, earrings, finger rings, pieces of chain, nibs and pedestals.

- Iron rails, clamps.
- Arrow heads.
- Iron knives

Coin Moulds

In the citadel area, baked honey combed clay slabs, about half an inch thick and broken into fragments, were observed at places on the surface and also in the upper levels of the excavations. On the upper side of these cakes or slabs are impressed rows of little cup like hollows of different sizes forming a regular honey comb pattern, which on the lower side has been subjected to great heat and is vitrified. They were variously interpreted by the explorers as a type of crucibles for smelting copper. These slabs were connected with the local coin making device. They were found in association with charcoal and ashes, crucible fragments and copper coins. Small sized local coins had also been produced subsequently in the dies by a heavy blow from the sledge hammer. The small silver coins of Banbhore, too, were made apparently in the same way. Such coins and coin moulds have been observed in many other contemporary Islamic sites of the subcontinent and the neighbouring areas.

ACKNOWLEDGEMENT

Authors are grateful to Mr. Abdullah Weryah, a famous land lord of Tando Adam, Sindh who had the hobby of collecting old coins study and Dr. Sharif, Department of Archaeology, Karachi, for supplying a piece of iron antique for analysis by the permission of DG Archaeology Department.

BANBHORE-SHAH LATIF's IMMORTALIZED CITY OF LOVE

The archaeological evidence yielded to spade at the Banbhore excavations, not only guides about the source to a great extent but also provides fresh ground for solving the problem of the identification of the site. Because Sindh had remained a part of caliphate since the early years of the 8th century, its cities, routes and harbour towns have been described by the Arab geographers and historians. Among the cities of Sindh under the Arab rule, the corresponding Banbhore as name of place does not occur in these sources, but of course the legendary Banbhore was associated with the local Sindhi love and romance of Sassi-Punnhoon.

The famous saint of Sindh, Shah Abdul Latif of Bhit had observed himself the site of Banbhore and also added new dimensions to the old romance, by immortal lyrics. Mir Alisher Qani Thattavi, who completed his work in 1773 A.D. was the earliest historian to mention Bambhore as the name of place. Thus, it is evident that the excavated site of Bambhore was not known by its present name, when the port city came to light during the Sassanid and Hindu dynasty. Its people enjoyed a prosperous life under the Arab rule. Probably, it assumed the name Bambhore in the early 18th century.

Banbhore was connected with the interior of the country by a branch of the Indus. Its identification with Debal, the famous Hindu port has been mentioned by many historians.

The large scale excavations have revealed the plan of the well fortified harbour of considerable size with some details of art, architecture and wealthy objects of early Islamic period.

The large pottery collection, in particular, has enabled the excavators to study and classify for the first time the early Islamic pottery of the sub-continent. Deep diggings at half a dozen points have provided an almost complete cross

section of the mound from top to bottom, revealing the remains of three distinct periods.

1. The Scytho Parthian.
2. Hindi Sessanian and
3. Early Islamic datable from the 1st century to 13 century A.C.

It is interesting to note that Indo-Pakistan, particularly Sindh, was as much concerned as other Islamic kingdoms with scholastic and religious problems of the time.

It is also remarkable that the famous port City of Debal was the center of the trade in South Asia. Muslims from all corners of the Islamic world gathered at Debal for trade and commerce till the prosperity of the port city of Debal declined and faded into oblivion.

The coinage of Sindh provides a wide field of a very interesting study. The lack of original coins, has made a complete and thorough study very difficult. However, the coins uncovered during the archaeological spade work have provided us glimpses of this very interesting subject. The historical accounts of Sindh specially after the Arab conquest, provide us some informations about the coins in Sindh.

In about 90 B.C., the Scythians over threw the Bacterians. According to Cunningham, there were three distinct dynesties of the Scythians, one of which ruled over Sindh and Western Central India to which the great Nahapana belonged. The coins struck by the scythians in Sindh are still not known.

The only reference to the Hindu coins immediately before the Arabs is found in Chach Namah in connection with Raja Dahir.

Within a short period after the fall of Debal, the Muslim rule was further extended to north upto Multan and firmly established. It was after the capture of Multan that Mohammad Bin Qasim was instructed to struck local coins in

the name of caliph. During the Umayyid and Abbasid periods, new Arab cities like Mansura and Mahfooza were established.

Two and a half centuries, after Mohammad Bin Qasim, Ibn-Hauqal after describing Mansura says, "The current coin of the country is stamped at Kandhar. One of the pieces is equivalent of five dirhams. The Tatari coin is also current, each being is weight equal to a dirham. They likewise use Dinars".

Idrisi tells us that "The money is silver and copper". The weight of dinar is five times that of the ordinary drachma."

Khairpur, was a mint town of the Mughal in Sindh, but only few copper coins of Akbar from this mint are known. Debal Bunder was an old port not far from Thatta. Few specimens of Akbar's Ilahi type coins are known from this mint.

Sindh, a mint of unknown topography is known to us, from a few half mohar coins of Muhammad Shah. It also appears on silver coins of Nadir Shah, as of a Durrani Mint.

Bhakkar, a fortress on an island in the River Indus has been described as a mint of copper coins of Akbar in the Ain-i-Akbari. The coins of Akbar, Shah Jahan, Aurangzeb, Muhammad Shah and Ahmad Shah minted at Bhakkar are known.

Some details have been given by experts. On the actual striking of the coins, coin moulds are found at Banbhore. These honey combed clay slabs have been found in association with charcoal, ashes and fragments of metal. The fragmentary copper pellets which fit in hollows of these slabs, suggest that coins moulds provided ingots of uniform size and weight.

The Arab coins found their way into the towns and cities of Sindh, which was the far eastern province of the

Caliphate. As a result of Archaeological excavations at Banbhore and Mansoorah a large number of coins belonging to the Arab period have been discovered but most of them are badly corroded and totally undecipherable. However, decipherable Islamic coins from Banbhore have been studied and published. These coins fall in two distinct categories i.e. Pre-reform and post-reform coinage. The pre-reform coinage is further classified as Arab-Sassanian and Byzantine coins. The Arab-Sassanian coins were in silver or copper. The coins were struck on the Sassanian pattern i.e. with a conventional portrait on the obverse and a Zoroastrian fire altar on the reverse with the addition of Bismillah of Allah. It is interesting to note that four languages with their corresponding scripts i.e. Pahlavi, Ephthalite, Bukkaran and Arabic were employed to express the legend. The legends on Arab Byzantine coins were sometimes in Pahlavi with Arabic inscription superimposed on them.

The copper coins 'Fulu's were looked upon as token currency and there was no fixed weight for them as they provided small change for petty transactions. The legend consisted of the name of the mint, year of minting, Kalima and or a verse from the Holy Quran. It is interesting to note that unfortunately, the name of the caliph was not given on these coins.

Silver coins of the seventh Abbasid Caliph al-Mamun (813 A.C - 833 A.C), dated 196 A.H. (811 A.C) were minted from Samarkand. Below the name of the Caliph, his two titles Amirul Muminin and Al-Fadl' are given. Since his elder brother, Al-Amin was assassinated in 198 A.H/813A.C., he could not have been accepted as the undisputed Amirul Muminin before that year. The mention of this title is therefore intriguing. The other title refers to as the possessor of two authorities the pen and the sword.

A silver coin of the fifteenth Abbasid Caliph Al-Mutamid Alallah (870 A.C - 892 A.C) with the badly defaced obverse of the coin, where the date was given, shows only the last two

numbers 61 A.H. But since the name of the Caliph on the reverse is clear, it seems reasonable to read the date as 216 A.H. (874/75 A.C). The name of the mint is not clear.

Preliminary studies of the better preserved and decipherable coins have yielded significant informations. Among them, the following important coins deserve a special mention:-

Two silver coins of the sixth Umayyad Caliph al Walid ibn Abd-alMalik (705 A.C - 715 A.C) both of them bear the same date of 95 A.H (713 A.C), but two different mint names of Taimurah and Ardashir Khurrah, respectively, in addition to the usual 'Kalima' and the Quranic verses. Incidentally, it may be mentioned here that Debal was conquered by the Arabs under Muhammad Bin Qasim during the reign of al-Walid I, and only a year earlier then the issue-date of this coin.

A silver coin of the tenth Umayyad Caliph Hisham Bin Abd al-Malik (724 A.C - 743 A.C), it is dated 124 A.H (741/42 A.C) and was minted from Wasit. The name of the Caliph has not been mentioned in this, and also in the above coins. This is not an unusual practice. In fact, Islamic coins prior to Hajjaj bin Yusuf's time did not bear the names of the rulers. It became customary from the days of Abbasid rule only, probably as a measure to assert their right to the disputed Caliphate.

Three copper coins bearing the name of Hisham bin Amrw, a popular governor of the second Abbasid Caliph Al-Mansur (754 A.C - 775 A.C) in Sindh from the year 768 A.C to 773 A.C. The name of the mint and date is not clear, which initially led to a confusion of mixing up his name with that of the 10th Umayyad Caliph.

Of the minor antiquities, the most important are the coins, which have yielded valuable and significant datable evidence. The corroborate the evidence of inscription and other cultural material serve as a basis for the reconstruction

of chronological development of the site.

Pre- Islamic Coins

Only a very limited number of coins have been recovered from the pre-Islamic levels at Bambhore. Among them, the best preserved specimen represent an Arab-Sassanian coin bearing, on the obverse, the bust of a typical Sassanian ruler and a short legend in Pahlevi, and on the reverse, a fire altar, mint name, and date in Yezdgrid era. The mint name has been read as Mary and the date as 21 Y.E (Yajvist) i.e. 32 A.H./652 A.C.

The most interesting fact about this coin is that the pahlevi legend on the obverse has been subscribed by a Kufic line, Bismillah. It is quite a known fact that Byzantine and Sassanian coins were in circulation throughout the caliphate before the reign of Abdul Malik Ibn-Marwan, sometimes with the insertion of only "Bismillah" or merely "Allah" in Kufic on their usual legends, to indicate the authority of the Arab Empire. Abdul Malik is credited to have started the pure Arab coinage in the year 696 A.C.. Thus Bambhore coin is a fine specimen of the early Arab coinage.

Two partially preserved Indo-Sassanian silver coins are interesting in the present decayed condition, they are without any legend. On their obverse, the profile of a face is somewhat recognizable, while on the reverse there is a crude representation of the Persian fire altar. This type of coins is commonly known as Gadlhaiya, probably because the distorted relief of the facial profile gives roughly the appearance of an ass. Its origin is attributed to the legendary Vikramaditya of Ujjain (441 A.C). Its period of currency in Gujrat and Rajputana is stated to be from about 750 A.C to 1100 A.C.

A copper coin with a squatting bull on one side and two fish motifs facing opposite directions on the ruler. Similar, coins have been recovered from the ruins of the ancient city of

Montolle in Ceylon. Its date is not known.

A fragmentary and defaced copper coin with the lower part of a standing figure wearing a Kushan type dress within a beaded circle on the obverse, and a standing figure with trace's of a squatting bull at his feet on the reverse. The legends are completely obliterated. This could be a late Kushan coin showing the king on one side and Siva with Nandi, the bull, on the other. Its present state of preservation does not allow more positive conclusion about its date and origin.

Islamic Coins

A few thousand of coins have been recovered so far from the excavations. But unfortunately, most of them are in a bad state of preservation. After chemical treatments some of the better preserved specimen were found decipherable. They include more than a hundred copper and two dozens of silver coins, and also a gold coin in a very good state of preservation. It belongs to the ninth Abbasid Caliph Abu Jaffar Harun-al-Wasiq Billah who ruled in Baghdad from 227 A.H. to 232 A.H. (842 A.C to 847 A.C). It was minted in Egypt in 229 A.H (843 A.C). This coin was discovered on the lime-plastered floor of a burnt brick house in the northern part of the citadel.

Silver and Copper Coins

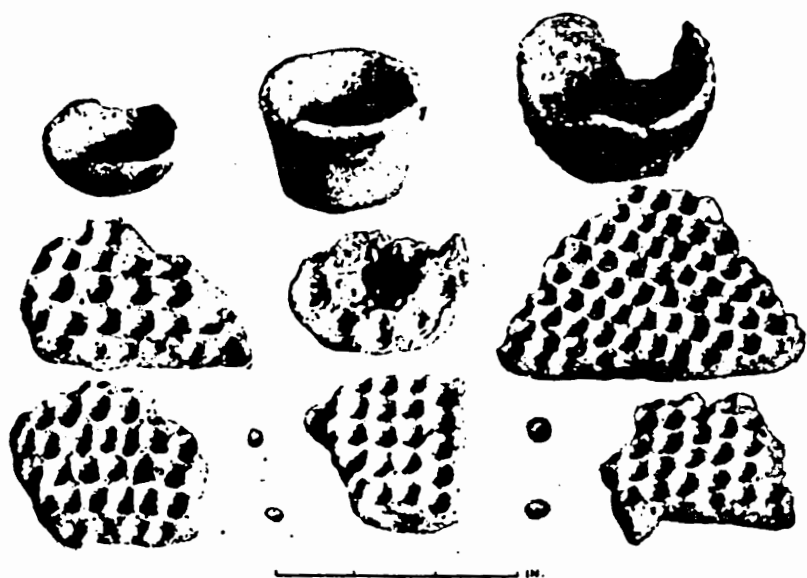
Out of the large collection of copper coins, only a small number has been successfully deciphered, the rest being still under study. The Bambhore coins are of two types, one is very thin and beautifully impressed with Arabic writing, partly inside a circle and partly around the rim. These coins belong mostly to the Caliphs of Baghdad or their local governors and were coined in the caliph's own mints. They found their way to Sindh either through trade of official imports for the provincial administration.

Antiques of Bhanbhore



Iron object

The other types, squat and dumpy and of smaller size, appear to have been locally produced on a mass scale by unskilled workmen. They are so much corroded & the inscriptions, coarsely, and clumsily executed on them, and are so fragmentary that it has not yet been possible to decipher them with success.



Crucibles, terracotta coin moulds and copper pellets.

Some of the sand mixtures used during casting are given in table 1.

Table 1 : Example of sand mixtures

S. No.	MOULD	Archaeological period & Location	Dies/ Moulding Material	Coins material Alloys Cast	Fabrication/ Casting Technique	Special techniques to improve qualitative.	Source & year
1.	2.	3.	4.	5.	6.	7.	8.
1.	ERAN MOULDS	Ca. 3rd century BC Erann, (near Sanchi & Sagar Bina)	Bronze die	copper (plated later on by silver)	stamping & punching	*	Cunning ham (1880)
2.	ROHTAK MOULDS	Ca. 100 BC yaud heya mint, Khokra Kot, near Rohtak (40 miles from Delhi)	clay, (with grey dusting powder used as parting sands)	Bronze (cu + max 15% Sn)	Casting in clay dies. pouring from one sprue Cup connected with many radial runner	Quality of casting was improved by increasing porosity of clay by addition of husk and cereals.	SAHNI (1936) Dr. K. P. Jaswal.
3.	SUNET MOULDS	500 B.C. S-aunetra	clay (grey or red coloured)	*	Vertical main gate provided with branch	*	SAHNI *

runners for each disc mould.
 Molten metal entering each coin moulds, through these branch runners, after collecting at sprue base and rising in main gate.

4.	NALARDA MOULDS	Gupta period, Narasimha-gupta ca 500-550 A.C., Jayagupta Ca 625-675 A.C., Nalanda near Bihar	1. Dark grey 2. Teracotta mould. 3. Clay mixed with fabous vegetable matter but not well baked.	Gold in Nara Sinha Gupta period's moulds.	*	*	G. C. Chandra, Sehni 1935-36
5.	TAXILA MOULDS	Ca 15 B.C. King Azes period Sirkap	1. Black clay mixed with husk.	Rectangular & Disc moulds (Resembling	Finish was poor		SIR JOHN Marshal SAHNI

	near Texila Pakistan)	2. Terracotta, red clay,	the Roman moulds described by G. d. ATT, ARI)	
6.	ATRANJI KHERA MOULD	2nd Century A.C (Dasana period) Ranji Khera, Etah Dist., U.P.	* rectangular form sprue cup connected with branch runners.	* SAHNI
7.	MATHURA MOULD	not older than 2nd or 1st century A.C Kesha vadeva Katra, Mathura	* copper covered with silver alloy or silver (specially 5th to 3rd B.C)	* Dr. Panalal 1918, Durga parshad.
8.	SANCHI MOULDS	western Ksatrapa dynasty with in limits 150 & 388 A.C)	* terra cotta	* SAHNI
			* pouring from one sprue cup in joined discs (as seen in Roman moulds)	

9.	KONDAPUR MOULDS	1st & 2nd century A.C Kusapa period) & Andhra period	*	*	Punch marked	*	K.M Ahmad 1941.
10.	KADKAL MOULDS	11th - 12th century A.C Kadkul Daccan, Hyderabad.	*	*	*	*	K.M Ahmad 1936-37.

OBSERVATIONS:-

Tabulated in the form of the chart, from chapter XI: casting technique of Ancient Indian coinage.

- Has not been identified by the authors.

12TH CENTURY AD MUSLIM TECHNOLOGY

The steel of sword of Sultan Salahuddin Ayubi used during 12th century AD has been largely appreciated by archaeologists and metallurgists of modern times. Their swords were then known as Damascus swords or swords of Damascus steel. In 1819, Faraday (who also invented Dynamo & Electric motor) discovered that strength of type of steel is due to the presence of Si & Al in this steel. However, later on this idea was denied by French Scientist Robert Bernet. He for the first time discovered that strength of steel is due to the presence of C in steel. In order to manufacture this steel, special technique was applied. In first step, the iron ore was heated to red hot to deoxidize it and upgrated it by removing the gaunge minerals. Later on carbon was added in it after melting it at 1200-1300° C. The source of carbon was coal, charcoal, burnt wood and leaves of the trees. In microscope, this steel appears as Widman statten structure. In heat treatment of steel, the steel is heated to austenite range (850+30-50° C) then it is cooled as desired. If it is cooled rapidly (i.e. quenching), austenite changes into cementite (Fe_3C). It is very hard and brittle and accicular shaped micro structure. In case, if moderate cooling (cooling in still air i.e. nomalizing) the austenite transforms into pearlite (mixture of cementite and ferrite a micro constituents having very little carbon). In case of slow cooling (i.e. annealing, cooling in furnace by switching it off), the austenite transforms to pearlite of shorter size.

These heat treatment processes are carried out to impart specific mechanical properties to steel, e.g. annealing softens steel, while quenching develops hardness and brittleness. In manufacturing of swords of Damascus steel, the steel was first heated to austenite range and then it was suddenly quenched in warm brine solution. During this operation, carbon from cementite, collects on the surface. This developed hardness. Swords were then hammered to give sharp edge.

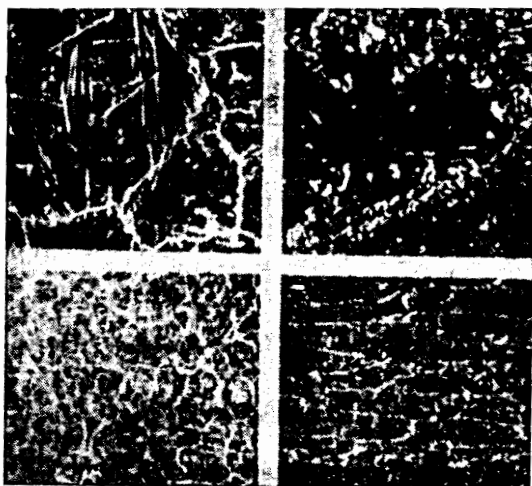
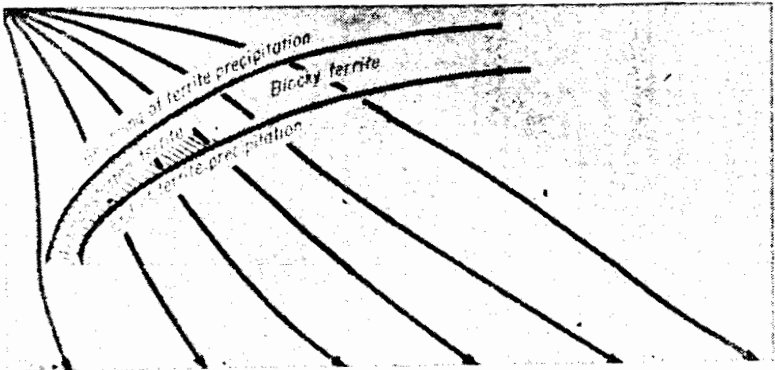


Figure 1) Micro structures of Damascus steel.

FIGURE 2

MICRO CONSTITUENTS OF CARBON STEEL
PRECIPITATION OF FERRITE WITH
RESPECT TO COOLING TIME

AUSTENITE



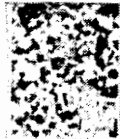
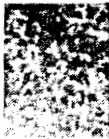
Time



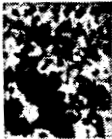
Martensite



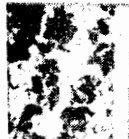
Widmanstatten ferrite
+ pearlite



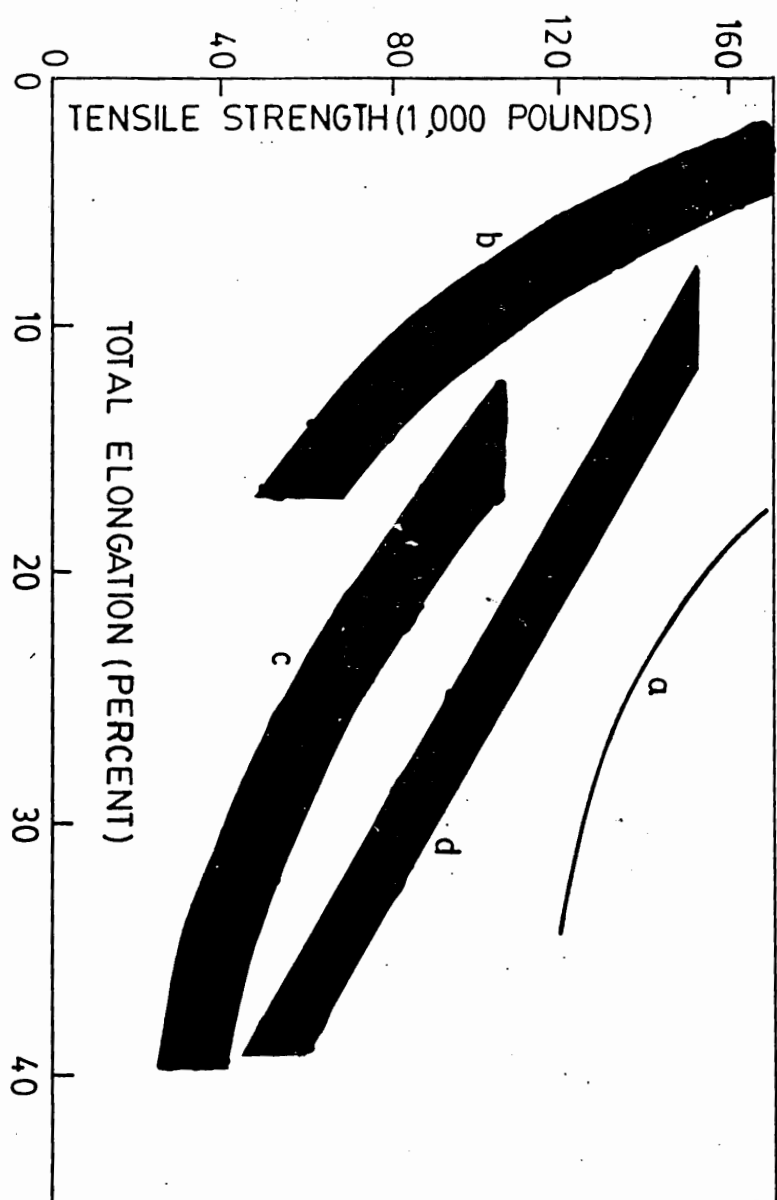
Widmanstatten + blocky ferrite
+ pearlite

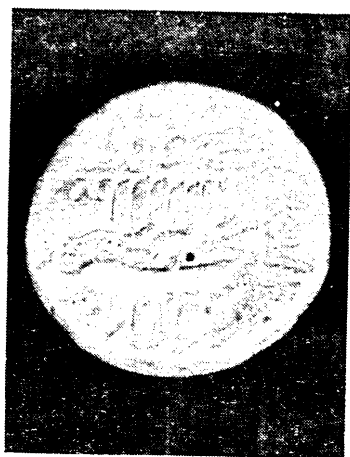
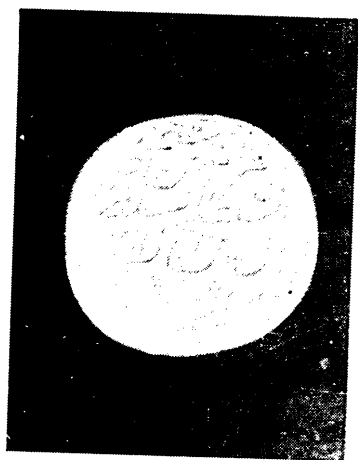


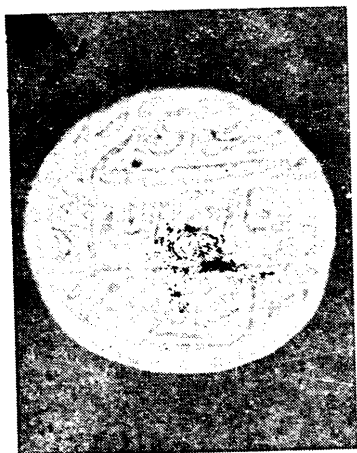
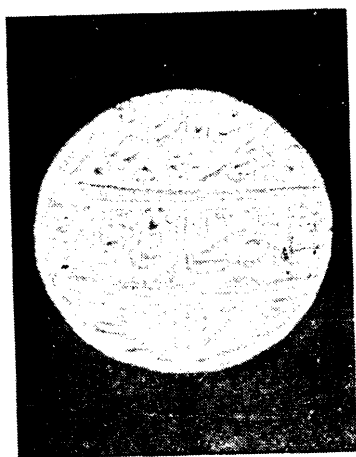
Random
blocky ferrite
+ pearlite



Dendritic
blocky ferrite
+ pearlite



Coins of Ancient Indus civilization



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Cultural Heritage of Sindh

Edited By:

Dr. Abdul Jabbar Junejo
Mohammad Qasim Bughio



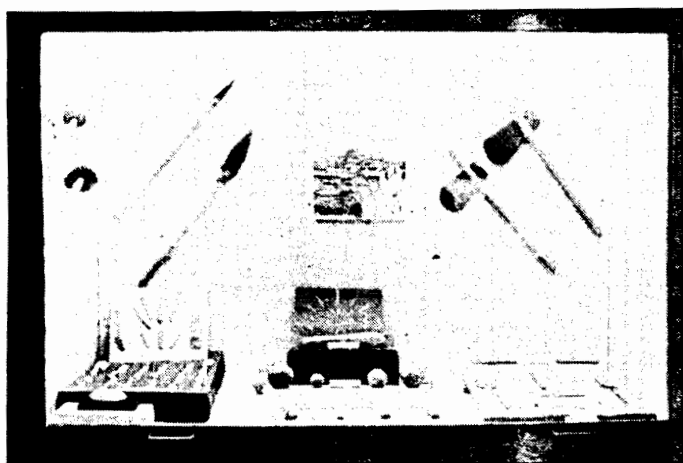
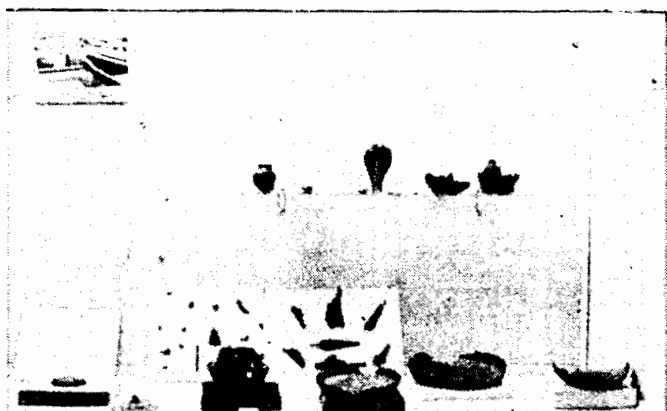
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Jamshoro, Sindh, Pakistan.

METALLURGY IN ANCIENT INDUS CIVILIZATION

DR. PARVAIZ HABIBULLAH

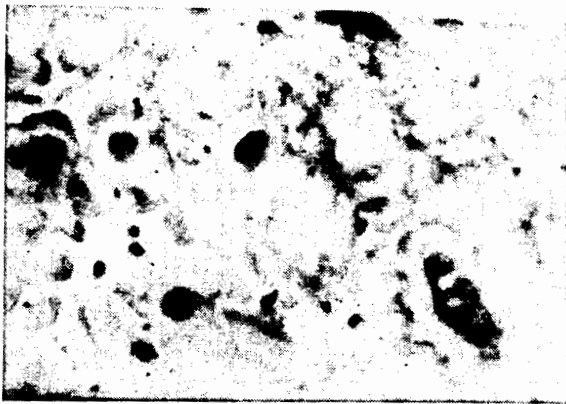
The discovery of numerous prehistoric copper and Bronze implements at Mohenjodaro indicate that its alloys were extensively used in the ancient Indus civilization. The antiquities collected from the excavations of Mohenjodaro have also shown that some of the other metals known to the early inhabitants of Indus valley were gold, silver, lead, and tin as an ingredients of Bronze, while iron was altogether unknown to them. The objects of metals comprise.

1. Domestic utensils.
2. axe-heads or clets
3. daggers,
4. knives,
5. lance head & arrow heads
6. sickles
7. statuettes
8. bangles
9. finger rings
10. ear rings
11. amulets
12. wires
13. rods etc.

Antiques of Mohenjodaro



Microstructure No. 1 Dendritic



Microstructure.2

Structure of Bronze (100 X)

Sources of Metals:

The respective sources from which these metals were obtained were uncertain, the metals may have been mined within the confines of India itself where all of them, including even tin are obtainable or they have been imported from the

neighbouring countries to the north or west, namely:

1. **Baluchistan:** where rich copper ore occurs at Shah Bellawal and at Robat. Large heaps of copper slag near the copper ore deposits indicate the ancient smelting of copper ore. Deposits of copper ore also occur in Ras Kuh and Kojak Amran range.

2. **Afghanistan:** Rich veins of copper ore exist in Shah Maqsood range while the deposits of gold, silver and lead are also found in Afghanistan.

3. **Persia:** Kalech Zeri (Kerman) and Anarek, at both of these places there is evidence of ancient working on an extensive scale.

4. **India:** The nearest copper mines in India proper are those situated near Ajmer, in Sirohi, Mewar and Jaipur states, notably those at Khetri and Singhana.

The presence of small quantities of Sulphur and absence of tin in the copper lumps point to the use of sulphide ore for the extraction of copper. Further more the presence of lead in some of the copper objects shows that some of the copper, at any rate, was obtained from Afghanistan and Baluchistan where copper ore associated with lead, exists in abundance.

5. **Arabia:** Where gold, silver and copper were found.

6. **Western Tibet:** Where gold is found.

The source of the tin which is an ingredient of bronze is difficult to locate. Tin ore is scarce in India proper and unknown in Baluchistan. The only Indian deposits, worth mentioning, exist in the Hazaribagh District, and appear to have been worked in ancient times. Tin occurs in the Kara Dagh District in North Western Persia. Strabo mentions that tin was found in Drangiana in the south-west of the modern Afghanistan, and ancient tin mines have been discovered by Van Baer in Khorasan, between Astrabad and Shah Rud. The rich deposits of cassiterite ore which occur in the Malay Peninsula and the neighbouring islands, that form the

Table No. 1

Analysis:

Typical analysis of the specimens of copper and bronze found at Mohen-jodaro are given below:-

CHEMICAL ANALYSIS OF COPPER AND BRONZE FOUND AT MOHEN-JO-DARO [1]

S.No.	SPECIMEN	COPPER	TIN	ANTIMONY	ARSENIC	IRON	NICKEL	SULPHUR	OXYGEN (by different)	REMARKS
1.	Copper Lump	96.76	0.00	0.88	0.15	0.03	1.27	0.98	-	Unaltered core
2.	Copper Lump	97.07	0.00	tr.	0.98	0.49	0.31	1.15	-	Unaltered core
3.	Copper Lump	96.42	0.00	-	0.00	0.00	0.35	0.36	2.78	Partly oxidized
4.	Copper Lump	92.49	0.37	tr.	1.30	1.51	1.06	2.26	1.01	Partly oxidized
5.	Fragment of some implement	95.80	0.00	0.72	0.74	0.12	0.25	0.61	0.18	Unaltered metal
6.	Celt	94.76	0.09	-	4.42	0.15	0.14	-	-	Unaltered and very hard metal
7.	Copper chisel (?)	92.41	0.00	0.10	3.42	0.59	0.15	0.05	-	Unaltered Portion
8.	Bronze rod	91.90	4.51	1.15	1.96	0.15	-	0.16	-	Unaltered core
9.	Bronze chisel	86.22	12.38	0.35	-	0.35	0.00	-	-	Completely oxidized
10.	Bronze buttons	88.05	8.22	2.60	tr.	0.29	tr.	0.84	-	Completely oxidized
11.	Bronze slab	82.71	13.21	0.33	1.17	0.42	0.56	0.00	1.49	Partly oxidized
12.	Bronze chisel	85.37	11.09	tr.	0.07	0.18	0.16	0.11	3.02	Partly oxidized
13.	Bronze Lump	83.92	12.13	tr.	0.00	0.00	0.17	0.00	3.61	Metallic core, partly oxidized.

Obs: Complete specimen, along with the adhering incrustation, was taken for analysis and the original composition of the alloy has been recalculated from the relative proportions of the metals found therein.

principal source of tin in the present age, do not appear to have been worked in early times. Moreover, a regular supply from this area which involved a long and perilous sea voyage, must have been impossible in those remote ages. The possibility of a supply from Hazaribagh must also be discounted, as the deposits are so meagre that they could barely have sufficed to meet local demands, and this assumption is amply justified by the scarcity of prehistoric bronze in the Gangetic Valley. Moreover, Hazaribagh was isolated by deep forests from Northern India down to historic times. It is, therefore, more than probable that the source of tin or bronze lay towards the North-west. It is noteworthy fact that the ancient tin mines mentioned above were accessible from the busy and ancient highway that traversed North Persia and Western Afghanistan and afforded communication by way of the Bolan Pass between the Indus Valley and the Western World. As copper was extensively worked in these regions in ancient times, it is not unlikely that the discovery of the alloy of copper and tin, by the accidental smelting together of the ores of these metals, also took place somewhere in North Persia, and thence found its way to the Indus Valley. In this connection it is a significant fact that the daggers and knives discovered in the Indus Valley resemble some of the weapons found in Susa, Anau and in the South-West Caspian area.

Mechanical Properties

Considering different compositions of the Bronze found at Mohenjodaro, it will be possible to guess to a fair extent, the mechanical properties of such alloys. Majorally the hardness and other mechanical properties of a bronze depends on the content of Sn and some other alloying elements e.g. Arsenic, Zinc, Lead etc. Principal mechanical properties of some of bronzes used in different antiquities of Mohenjodaro are tabulated as follows:

Table No. 2

Mechanical properties of bronzes found at Mohenjodaro [5]

S.No	ANTIQUITY	% of Sn	other important alloying elements %	MECHANICAL PROPERTIES			Comments
				Tensile daN/mm ²	Elongation %	Hardness BHN	
1.	Bronze rod	4.51	Arsenic=196%	15	5	55-60	Arsenic increases hardness & decreases elongation.
2.	Bronze buttons	8.22	Antimony=260%	20	10%	60	Hardness increases with increase in content of Sn
3.	Bronze chisel	12.38	Lead=0.70	20-25	6	60-85	
4.	Bronze Slab	13.21	Arsenic = 117	25-28	4-5	85-100	
5.	Bronze Chisel	11.09	Oxygen = 300	20	10-2	67 to 70	
6.	Bronze Lump	12.13	-	20-28	6%	67 to 70	

Observation: Composition & Mechanical properties of different bronzes presently available are studied and compared with those of found in Mohenjodaro and nearest possible figures are mentioned in this table.

Metallography

Like mechanical properties, the microstructures of the bronzes found at Mohenjodaro can be predicted on the basis of their tin content and their comparison with standard samples of that composition.

Microstructures of Bronzes found at Mohenjodaro.

S. No.	ANTIQUITY	% AGE OF Sn	MICROSTRUCTURE
1.	Bronzerod	4.51%	Dendritic strucutre
2.	Bronze Button	8.22%	(α -Solid Soln,)

			Microstructure No. 1
3.	Bronze Chisel	12.38 %	Microstructure of
4.	Bronze Slab	13.21 %	Cast Byphasic
5.	Bronze Chisel	11.9 %	Bronze. α -Solid
6.	Bronze Lump	12.13 %	Soln non-homogenous & eutectoid ($\alpha + s$) Microstructure No. 2

Consulation

1. The coppoer Bronze antiquities found at Mohenjodaro prove that melting, casting and working oi different compositions were well known to the inhabitants of Mohenjodaro.

2. Art of casting bronze was a well established industry at Mohenjodaro. Bronze dish and its cover (dimensions: 6.55 in diameter, 0.95 high, cover slightly more in diameter, both together stand 2.6 high) seems to be cast either with excellent surface finish or after casting had been fettled by carefully rubbing or had been trued up on the lathe. No marks of machining on the lathe are visible but these could have been removed by subsequent honing and polishing.

3. Old inhabitants of Mohenjodaro were well versed in Sand moulding. Models of different animals e.g Bull and simple axes were first cast in open moulds and then hammered to requisite hardness. Similarly the chisels were first cast in mould in form of square or rectangular rods of metal and then hammered and sharpened on the one side.

4. For making bronze utensils the metal was first hammered in the form of the sheet and then vessels were raised from this sheet. Copper was an ideal material for making these utensils being soft and ductile. Bronze is less ductile but considerable stronger and less liable to damage.

Acknowledgement

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DESIGNING AND FABRICATION OF WIND TUBE FOR MELTING AND CASTING OF LOW MELTING POINT ALLOYS

Dr. Parvaiz Habibullah*

ABSTRACT

Hyderabad is situated on the wind belt extending from Karachi to Khokharaper (Pakistan). The velocity of wind at this wind belt is recorderd as 30 miles per hr (max), and 5 to 7 miles per hr (min). We have fabricated a wind tube and utilized wind energy formelting of alloys in pit furance. It is a hallow, taperedtube, with three sections prependicular to each other. As coke in the pit furance ignites, flue gases leave furncae rapidly suction is created, enforeing the natural air to enter in furncae through the pipe at high speed due to its tapered profile. This wind tube was tested in a foundry at Kotri near Hyderabad, Pakistan and aluminium, Brass and cast iron with highfluidity were melted in pit furnace fitted with this tube. Advantages offered are: economy of energy by eliminating the electric blower, simplicity of the operation and its utilization in under developing areas, lacking in sources of energy e.g electric power, gas energy etc. This project has been submitted to the FARQALEET ENGG IND. Hyderabad for implemention.

INTRODUCTION

Wind blowing at high speed has proved an effective source of energy during last half century. Most of the Wind mills developed in Holland, Denmark and other European

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countries have been used for different purposes of transmission of energy e.g for generating electricity, pumping water, grinding wheat etc. Energy from the wind depends upon the solar energy, as a small proportion of total solar radiation reaching on the earth causes movement in atmosphere which appears as source of power for surface. Wind has been used as source of power for thousands of years both at land and on sea.

We have not derived power from the high speed wind, on the other hand, it has been used for melting of different ferrous and non-ferrous alloys. Natural air blowing at any low or high speed passes through a specially designed, tapered, venturi pipe which is connected with a pit furnace. When coke takes fire, the flue gases ejecting from the furnace create vacuum, which is filled by air coming from the pipe. Taper design and venturies of the pipe feed air at very high speed which increases the rate of burning of coke thus creating sufficient heat to melt different alloys. Specially designed venturi pipe has been tried practically in a foundry at Kotri near Hyderabad, Pakistan, which comes on the wind belt.

WIND BELT - HYDERABAD DIVISION

In Hyderabad division, there is a belt on high wind velocity where the velocity some times reaches even 30 miles per hour, but this velocity is limited to a few hours annually. On an average, 10- 12 miles per hour may be considered a good figure for reasonable period during the year. This high wind velocity zone is roughly bounded by two parallel lines, one passing through Shah Bunder, Mithi and extending to Rajistan desert, and the other passing from Karachi to Hyderabad and going in to the desert beyond Chhor, up to Khokharapar.

The wind belt extending from Karachi to Khokharapar is shown in Map. 1. In this zone the following important stations are located.

1. Karachi.
2. Damloti.
3. Thatta.
4. Mirpur Sakro
5. Gharo
6. Sujawal
7. Mirpur Bathoro
8. Tando Mohammed Khan
9. Matli
10. Golarchi
11. Tando Bago
12. Tando Ghulam Ali
13. Kunri
14. Hyderabad
15. Tandojam
16. Tando Alaahyar
17. Mirpur khas
18. Jamesabad
19. Pithoro, and further down, all desert stations like:-
20. Cachro
21. Diplo
22. Chotal
23. Chorr, and
24. Kokharapar etc.

Meteorological Department of Pakistan has no wind recording station in this belt except at Karachi and Hyderabad. They have collected some data for Chhor. The data shows that the wind velocity of 20 miles per hour exists

for 1800, 15 for 3200 hours annually. The Indian Meteorological Department has an observatory at Jodhpur. It shows that wind velocity of more than 5 miles per hour exists during most of hours of the day, and more than 10 miles only during the month of June, July and August for only a few hours daily. It seems that wind velocity decreases from Karachi to Jodhpur, but is between 5-7 miles per hour at Jodhpur itself for most of the time. Considering the figures of Karachi, Hyderabad, Nawabshah, Chhoro (tables.1,2,3. and 4) one can safely assume that the wind Velocity of approximately 12 miles/hour will exist over 2000 hours in most of the desert area of Hyderabad Division. Therefore, wind tube is designed for that wind velocity. It is also to be considered for that wind velocity of 15- 20 miles per hour will be available for another 700 hours or so. In other words, the wind tube will be operative effectively on the average, about 7.5 hours daily. The wind velocities are more favourable for summer months.

WIND TUBE

Design

After studying a number of venturi tubes and knowing their rate of flow at different pressures, a wind tube, shown in the Fig. 1, has been designed. Such a tube must demonstrate:

1. adequate low rate of natural air, without any mechanical device (e.g. blower) fitted with the tube.
2. adequate pressure of air, at which sufficient amount of coke can burn to give such a quantity of heat which is sufficient to melt ferrous and non-ferrous alloys.
3. quick control of current of air.

In order to maintain maximum flow rate, a hopper has been provided at opening of larger diameter and to maintain

adequate pressure of air, the tube is made with tapered diameter and is divided in three parts.

a. horizontal -6" dia

b. vertical

- upper = 6" dia

- lower = 4" dia

c. horizontal

- right hand = 4" dia

- left hand = 2" dia

Data from the literature have indicated that for cast iron minimum debit of air to maintain adequate melting condition is $60 \text{ m}^3 / \text{m}^2 \text{ min}$. Velocity of air entering in the furnace depends upon depit of air [2, 4].

CALCULATION

Velocity of air in "Wind tube"

$$Q = AV = \text{constant}$$

Where Q is volume of air which passes through each cross section (A) of flow tube in unit time at velocity V.

By continuity equation, we have



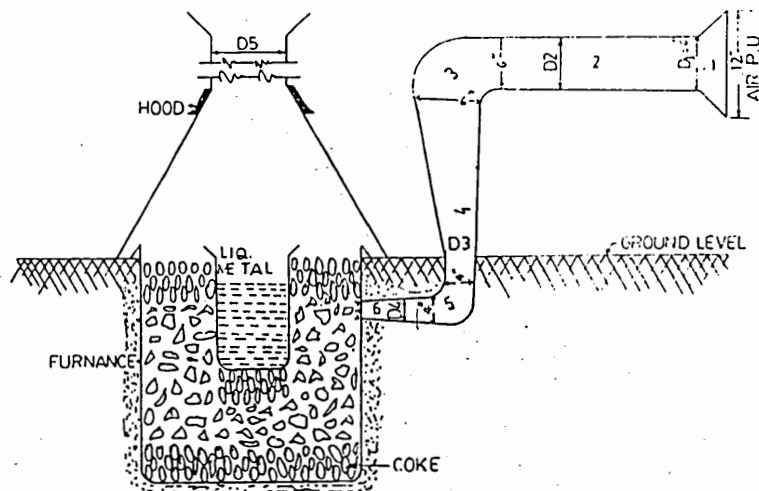


Fig.1 PIT FURNACE FITTED WITH WIND TUBE

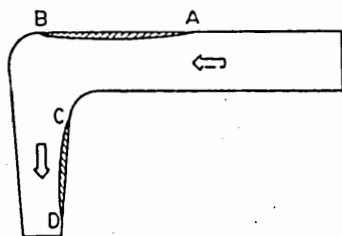


FIG.2 REGIONS SHOWING INCREASE & DECREASE IN PRESSURE IN A WIND TUBE.

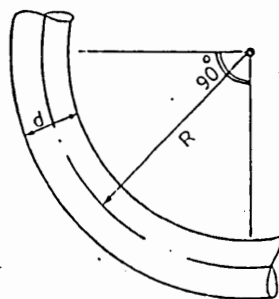


FIG.3 90° PIPE BEND

Table 1. Main Frequencies of wind Velocities in various Ranges Based on Six Hourly Observation.

Station: **KARACHI**

Month	0	1-3	4-6	7-10	11-6	17-21	22-27	(In knots per hour)
January	235.2	159.6	69.0	189.0	54.0	12.0	0.6	
February	241.0	144.0	78.0	156.0	18.6	9.6	0.6	
March	210.6	162.0	78.6	179.4	79.4	19.8	1.2	
April	157.8	130.8	94.2	198.6	118.2	16.8	2.4	
May	70.8	97.8	94.2	261.6	175.2	41.4	3.0	
June	38.4	71.4	81.6	292.8	169.8	52.2	10.8	
July	30.6	49.8	68.4	279.0	231.6	71.4	11.8	
August	31.2	49.8	67.8	358.2	190.2	42.0	4.2	
September	71.4	79.2	105.0	280.8	162.2	18.0	1.8	
October	294.6	120.6	79.8	179.0	52.8	6.0		
November	316.2	126.6	86.4	162.6	25.2	1.8		
December	269.4	181.8	93.6	169.8	29.4	1.2		
Total (Annual)	1968.0	1373.4	1023.6	2716.8	1344.4	282.2	36.0 Hrs	

Table 2. Main Frequencies of wind Velocities in various Rabges Based on Sox hourly Observation.

Station: **HYDERABAD**

Month	0	1-3	4-6	7-10	11-16	17-21	22-27	(In Knots per hour)
Janauary	188.4	236.4	106.8	115.2	7.8			
Febuary	215.4	295.8	91.8	60.6	4.8	0.0		
March	207.6	234.0	105.0	96.6	13.2	1.2	1.2	
April	260.2	226.8	122.4	163.2	43.2			
May	62.4	126.8	136.8	298.8	196.6	15.0		
June	16.8	90.0	108.6	271.8	180.2	36.6		
July	56.4	85.2	97.8	258.6	190.8	51.6		
August	75.0	103.2	107.4	298.2	141.6	17.4		
Septembe	1221.4	151.2	120.0	233.4	76.8	11.4		
october	298.4	234.6	102.0	103.2	6.6			
November	296.4	309.6	66.8	35.4	3.6			
December	207.6	318.0	136.2	78.6	3.0			
Total (Annual)	1897.4	2601.6	1301.6	2013.6	778.2	133.2	1.2 Hrs	

One Knot - 6020', or approximately 1-1/7 miles.

Table 3. Main Frequencies of wind Velocities in various Ranges Based on Six Hourly Observations.

Station: NAWABSHAH

Month	0	1-3	4-6	7-10	11-16	17-21	22-77	(In Knots per hour)
January	544.4	253.2	88.8	48.0	7.2			
February	363.0	187.8	65.4	56.4	6.0			
March	304.2	263.4	85.2	67.8	22.2			
April	264.0	207.6	20.0	180.2	26.4	1.2		
May	166.2	192.6	151.2	176.2	44.42	9.0		
June	63.6	116.4	153.0	261.6	104.4	18.0	1.2	
July	103.8	131.2	146.4	301.2	69.6	1.2	0.0	
August	118.2	151.8	171.0	233.4	64.2	3.0		
September	202.8	254.4	132.6	115.2	13.8			
October	224.6	237.0	94.2	84.2	4.2			
November	408.6	223.8	64.2	23.4				
December	394.8	231.6	81.2	34.8				
Total (Annual)	3058.2	2430.8	1323.6	1534.2	362.4	32.4	1.2 Hrs	

One Knot - 6020', or approximately 101/7 miles.

$$A_1 V_1 = A_2 V_2 \quad \dots\dots\dots (1)$$

Where

A_1 = Area of inlet

A_2 = Area where diameter is D_2

V_1 = velocity at inlet = velocity of air

V_2 = velocity where diameter is D_2

$$\text{-- } \pi/4 D_1^2 V_1 = \pi/4 D_2^2 V_2$$

$$\text{-- } D_1^2 V_1 = D_2^2 V_2$$

$$\text{-- } V_2 = (D_1/D_2)^2 V_1 \quad \dots\dots\dots (2)$$

Similarly

$$V_3 = (D_2/D_3)^2 (D_1/D_2)^2 V_1$$

$$V_4 = (D_3/D_4)^2 (D_2/D_4)^2 (D_1/D_2)^2 V_1$$

Velocity at outlet of wind tube, (V_1 = min air vel = 2.2 m/s)

$$V_4 = (4/2)^2 (6/4)^2 (6/6)^2 2.2$$

$$= 20 \text{ m/s}$$

Energy Losses

Pipe bends and curved flow channels also cause energy losses. Considering the typical case of

R/d	1	2	4	8	10
Smooth	0.21	0.14	0.11	0.099	0.11
Rough	0.51	0.30	0.23	0.18	0.2

(1) wind tube in the elbows, the streamlines are curved and centrifugal forces cause a pressure increase near outwall of the elbow starting at point A (Fig:2) and using the maximum value at Pt. B. Therefore in the region AB the fluid flow is opposed by an adverse pressure gradient. At the inside of the elbow, the pressure decreases at point C and rises in exit section. The magnitude of these losses largely depends upon sharpness and curvature of the elbow.

Losses in 90° elbow have been measured in both smooth and rough pipes³. The energy losses are

(2) generally confi of friction head, h_f .

$$h_f = \frac{\bar{V}^2}{2g} \Sigma$$

where the coeff. Σ is determined for the range of Reynolds No. Re and R/d ratio where R is radius of curvature and d is the pipe diameter. The smaller the R/d , the larger is Σ .

Also in the rough pipe (relative roughness 0.012 at $Re = 1.5 \times 10^5$) Σ is nearly twice as large as smooth ones. It decreases in the smooth pipe with increasing Re , while in rough pipes, it rapidly approaches to constant value. The following table gives approximate value for Σ at $Re = 2.25 \times 10^5$.

FABRICATION

1. Mild steel sheet of SWG 16 was cut by the shearing machine, in three pieces.
2. Each of these pieces was individually joined end to end, by oxy-acetylene gas welding, (Neutral flame of temp. 2950°C).
3. The elbow portions 3 and 5 (Fig.1) are made separately.
4. These two portions are welded among three above mentioned pipe pieces and hopper of 1 ft dia is rivetted at the larger opening to give it final shape of wind tube.

MELTING OF ALLOYS

Pit furnace of 1.5 ft cross-section and 3 feet depth was prepared. At the bottom of the furnace, wind tube is fixed. Furnace is dried fully with gas flame and bed of coke is prepared. Coke is ignited and when it catches fire crucible containing scrap of aluminium alloy is placed on the coke bed. Crucible is covered with hood. As flue gases leave furnace rapidly through the hood, suction is created and air rushes through the wind tube. The speed of the wind is further accelerated by venturuses of the tube. When content of crucible comes in liquid form and attains sufficient fluidity, liquid alloy is poured in the mould. Similarly brass bronze and cast iron are melted.

When the tube was covered with a hood with chimney extending upward upto 3 1/2 feet or more the rate of burning of coke increased, consequently decreasing the time of melting of alloy.

Table 4. Main Frequencies of wind Velocities in various Ranges Based on Six Hourly Observations.
Station: **CHHOR**

Month	0	1-3	4-6	7-10	11-16	17-21	22-77	(In Knots per hour)
January	378.3	236.4	106.8	115.2	7.8			
February	338.4	295.8	91.8	60.6	4.8	0.0	1.2	
March	296.4	234.0	105.0	96.6	13.2	1.2		
April	206.4	226.8	122.4	163.2	43.2			
May	79.2	126.8	136.8	298.8	196.6	15.0		
June		90.0	108.6	271.8	180.2	36.6		
July	62.4	85.2	97.8	258.6	190.8	51.6		
August	16.8	103.2	107.4	298.2	141.6	17.4		
September	56.4	151.2	120.0	233.4	76.8	11.4		
October	75.0	234.6	102.0	103.2	6.6			
November	122.4	309.6	66.8	35.4	3.6			
December	298.4	318.0	136.2	78.6	3.0			
	296.4							
	207.4							
Total								
(Annual)	1897.4	2601.6	1301.6	2013.6	778.2	133.2	1.2	Hrs

One Knot - 6020', or approximately 1-1/7 miles.

Table 5. Type of the winds blowing in the wind belt extending from Karachi to Khokharapar. (Pakistan).

Wind	Vel. Miles/hr	Pressure of air lbs/sq. ft/hr
Brisk wind	20	1.08
	25	1.69
High wind	30	2.44
	35	3.32
Very high wind	40	4.34
	45	5.49
Storm	50	9.79
Great Storm	60	13.3
	70	17.3
Hurricane	80	22
	100	32.8

Table 6. Influence of Debit of Air.

Characteristic	Experimental Values			
	Initial Value without Hood	With Hood of		Variation
		3" height	9" height	
Debit of Air m^3/m^2 Min	38	45	66	+7 to 28
Quantity of Oxygen	7.98	9.45	13.86	+ 1.47 to 5.88
Introduced m^3/m^2 Min				
Temp: Al	665° C	-	-	-
Brass		1100-C	-	+ 435° C
Cast iron		-	1370° C	+ 705
Coff. of * burning n_v %	29.1	34.5	50.0	+ 5.4 to 20.9

$$* nv = \frac{CO_2}{CO_2 + CO} m^3 / m^3$$

Table 7. Comparative study of different furnaces used in small foundries.

S.No.	Type of Furnaces	Fuel Used	Furnace fitted with	Duration of Melting Min/Heat of 40 Kg.			Comments
1.	Oil Fired * furnace	Furnace Oil	Blower motor of 1 HP	15	30	60-75	-
2.	Gas fired * furnace	Natural gas (88% CH ₄)	Blower and motor of 1 HP	25	45	-	Temp. is not sufficient to melt cast iron
3.	Coke fired * furnace	Hard coke (fixed C 85%)	-do-	20	35-40	100	-
4.	Pit furnace	-do-	Wind tube & hood over furnace	20-25	-do-	110-120	Saves electric energy and is comparatively economical

INFLUENCE OF DEBIT OF AIR

Quantity of air introduced in cupola to melt cast iron varies between $60\text{--}200\text{ m}^3 / \text{m}^2\text{ min}$. For melting cast iron, the debit of air in wind tube is approximately $66\text{ m}^3 / \text{m}^2\text{ min}$ but non-ferrous alloys may melt at comparatively lower debit of air. Debit of air mainly depends upon the rate of burning of coke.

The increase in debit of air increases pressure and velocity of air blowing through the wind tube. Table 6 summarizes some data concerning influence of debit of air on the temperature of the alloy and coeff of burning. Duration of melting of Al. Brass and cast iron in gas, coke and oil fired with wind tube and hood over the furnace, is given in the table 7.

CONCLUSION

After experimentation following conclusions have been deduced:

1. The wind tube designed and fabricated by the authors can effectively utilize wind energy for melting of ferrous and non-ferrous alloys (eg. cast iron, Brass, Al. etc.) with high fluidity.

2. The advantages of this wind tube are its comparative simple construction and operation freedom in choosing the location and its utilization in under developed areas lacking in sources of energy like electric power, gas energy etc.

3. Main disadvantages are the unpredictability of wind. Even in very windy places there is no certainty that wind will blow at sufficiently high speed at a particular time when it is needed most.

4. The debit of air in the wind tube depends upon rate of burning of coke and its grains. Increase in debit of air increases pressure and velocity of air and temperature of flue gas. This is due to increase in quantity of oxygen with

increase in quantity of oxygen with increase in debit of air.

5. Time of melting different alloys considerably decreases by putting hood of long chimney, on the furnace fitted with wind tube but still it is comparatively greater than that of oil & coke fire a furnace fitted with electric blower. Melting in furnace provided with wind tube is still considered economical because it saves electric power or extra labour and care if furnace is run by belows. This wind tube can be effectively utilized in the area as Arid Zones of Sindh, Pakistan, lacking in sources of gas and electric energy.

ACKNOWLEDGEMENT

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Wind Tube

SOLAR ENERGY IN POWDER METALLURGY

Dr. P. Habibullah

ABSTRACT

Experiments have been carried out to produce copper and other metals powder. The technique essentially consists in getting electrical energy from the solar cell (max: 40 watts) and using it for electrolysis of Cu SO₄ and other electrolytes. In three series of experiments the effect of temperature of sun normality of solution and current density, on the weight of the metallic powder obtained during electrolysis has been studied and as the result of this research the optimum conditions for getting maximum copper powder have been determined.

INTRODUCTION

Powder Metallurgy is the best technique for manufacturing the machine parts of the specific characteristics. It enables to produce the machine parts mixture of metallic and non metallic powders, articles of controlled porosity, high melting point, strength, harness and formability. A quarter century earlier Powder Metallurgy was in embryo and it was utilized only in manufacturing the structural parts and porous materials. But now-a-days some of the most important materials utilized in the fields of Nuclear Metallurgy (compact mixture of UO₂ + stainless steel and Al powder used as fuel in atomic reactor), space science, tool manufacturing, automobiles, refractories and ceramics, electronics and machine parts of special characteristics are also manufactured by the Powder Metallurgy techniques.

EXPERIMENTAL

SOLAR CELL

We have used Silicon solarex cell with maximum capacity of 40 watts, for our present research. This contains 32 cells connected in series and delivers 16 volts and 2.5 amperes. It is equipped with special power conditioner which prevents overcharging of the storage batteries and also avoids the risk of discharging of batteries during period of darkness. It is fitted of a typically mounted anodized aluminium frame, with enamel painted surfaces, for maximum resistance of corrosion. It is light and can be easily transported to site.

The mechanism of generation of electric power from solar energy in case of silicon solar cell is as follows:

Silicon solar cells are made by doping pure, Cylindrical silicon crystals with other chemical elements. When phosphorus is added during the growth of the crystal, the silicon develops negative charge carriers (electrons). When Boron is added positive charge carriers appear. The crystal cylinders are then sliced into wafers. High temperature diffusion of phosphorus into a boron doped silicon creates an n-type to p-type junction and a built-in field. When the diffused silicon slice is illuminated in-coming units of light energy (photons) are absorbed by the electrons within the silicon wafer. This creates negative charge which are attracted to the p-type. A photo current flows, voltage develops and electricity is produced. Thus a power source is created.

The amount of electrical power delivered by solar cells depends on their size and efficiency. Solarex silicon solar cells are the largest and most efficient. Normal solarex cells are 60 mm, 75 mm and 100 mm in diameter. They are 15% efficient. Recently introduced rectangular 5 X 5 cm solar cells have proven themselves as most efficient cells.

All solar cells, when exposed to light, produce about the same voltage i.e. about 0.5 V. However the amount of current

varies with the light intensity and the surface area of the solar cell. Solar cells are responsive to a broad range of light spectrum, from ultraviolet through the visible to the infrared. Therefore the cell produces energy even on fairly overcast days and in ordinary room light.

ELECTROLYSIS

Electrolysis of aqueous solution of different salts and minerals are carried out to produce powders of number of metals, both on the laboratory and industrial scales. Commonly the deposition of slimes of spongy or powdery nature during electrolysis is considered disastrous for ordinary electrolytic work (i.e. electroplating) but contrarily in powder metallurgy it forms the basis of majority of commercial processes for manufacturing of electrolytic metal powder. Electrolytic processes are classified into three distinctly different methods:

- a. Deposition of hard, brittle metal, a powder being obtained by mechanical comminution e.g. grinding.
- b. Deposition of soft spongy substance, a powder being obtained by pulverizing e.g. light rubbing, and
- c. Direct deposition of a powder from electrolyte.

Powders obtained by the first method are generally unsuitable for molding purpose but large quantity of electrolytic powder ideally suited for many applications are manufactured by last two Methods.

Sulphates are the most frequently used salts for the electrodeposition of copper, iron, Nickel powders. In the present researches the powders of copper Nickel and iron are produced by electrolysis of aqueous solutions of CuSO_4 , NiSO_4 and FeSO_4 . A little quantity of H_2SO_4 was added for better conductivity of electrolyte. Bath temperature was maintained at 28 to 30° C. Keeping all other factors constant, effect of following factors on the weight of copper obtained by

electrolysis of Cu SO_4 was studied experimentally.

- a. Temperature of Sun
- b. Normality (conc) of electrolyte and
- c. current/current density.

In each experiment, one litre of electrolyte is prepared in a beaker. Two stainless steel plates, each with 4-in breadth, were used as anode and cathode. The time of electrolysis was fixed between 15-30 mins. Minimum distance between the plates was 3 inches.

Effect of temperature of Sun

Effect of temperature of Sun on the quantity of copper powder deposited on the cathode was studied experimentally with an electrolyte of normality 1.

$$\begin{aligned}\text{Cu SO}_4 \text{ Soln} &= 63.54 + 32 + 32 \\ &= 127.54 \text{ g in} \\ &\quad 1000 \text{ c.c. of water}\end{aligned}$$

Circuit diagram is shown in Fig. 1 copper powder in the form of globules was collected from cathode after 1/2 hours of electrolysis. The readings were taken when temperature of sun falling on the solar cell was 44°C , 42.5°C , 38°C . The powder collected from cathode was dried and weighed. Voltage across the plates and current was measured during electrolysis and results obtained are given in Table-1.

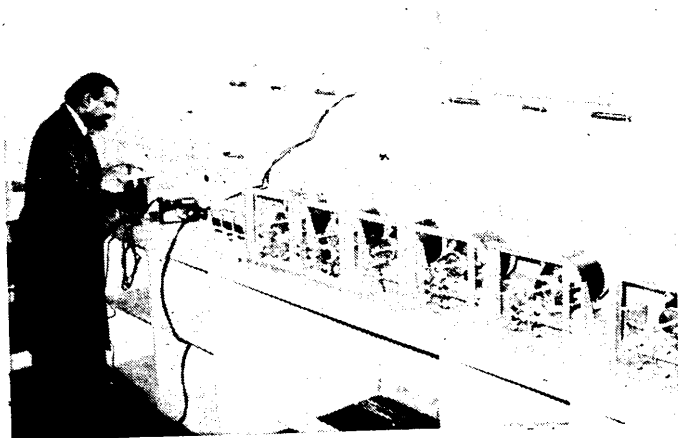
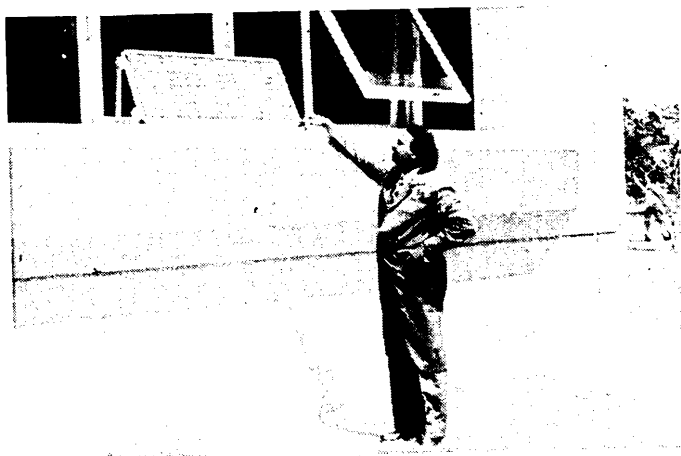
Effect of Normality of Solution

Cu SO_4 aqueous solution with different normalities e.g. 0.133 N, 0.266N, 0.37N, 0.665N and 1.33N were subjected to electrolysis. All other conditions including the Sun temperature remained constant. Fig.1 shows the electric circuit used for this series of experiments. The results are given in Table-2.

Effect of Current density

Current supplied to electrolyte was kept constant at

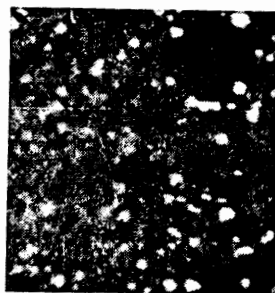
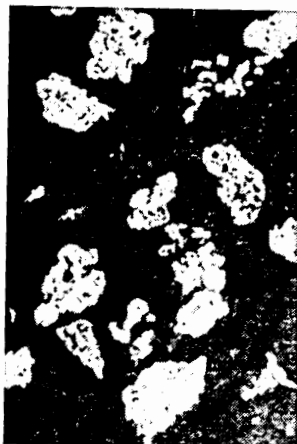
Solar Cell (40 W)



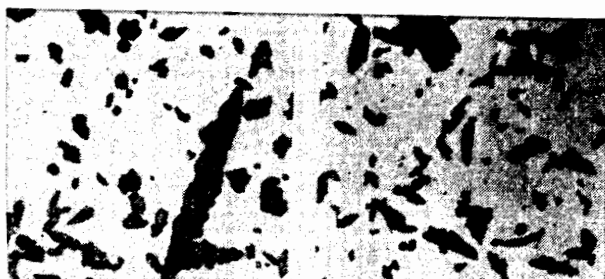
Experiment

Fig 3. Macrostructure of powder

a) Cu powder



b) Ni Powder



c) Fe Powder

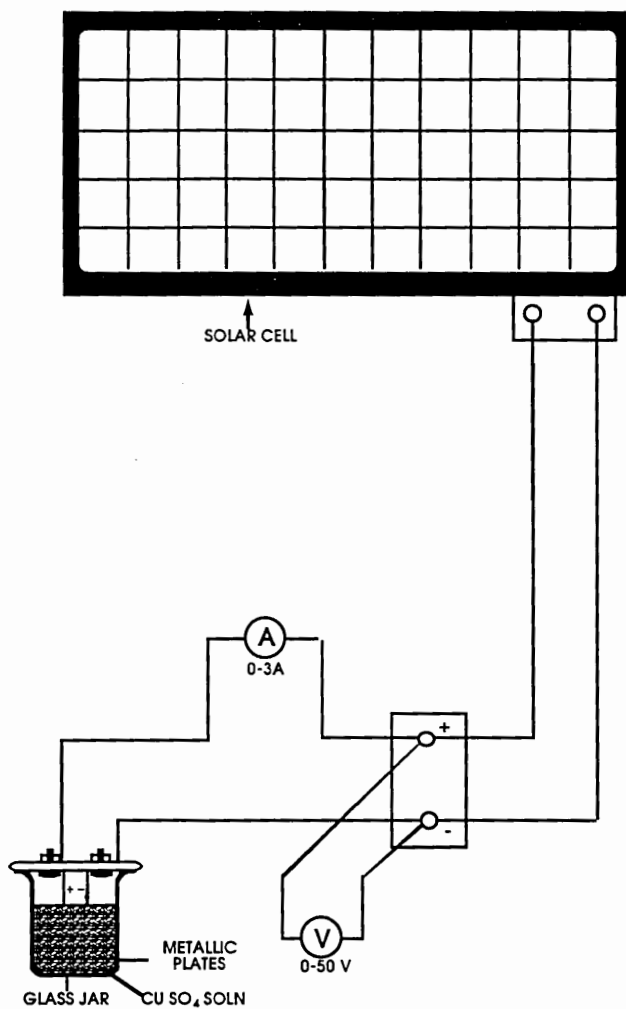


FIG 1: PRODUCTION OF COPPER POWDER BY ELECTROLYSIS OF CuSO_4
CURRENT USED IN ELECTROLYSIS IS PRODUCED BY SOLAR CELL.

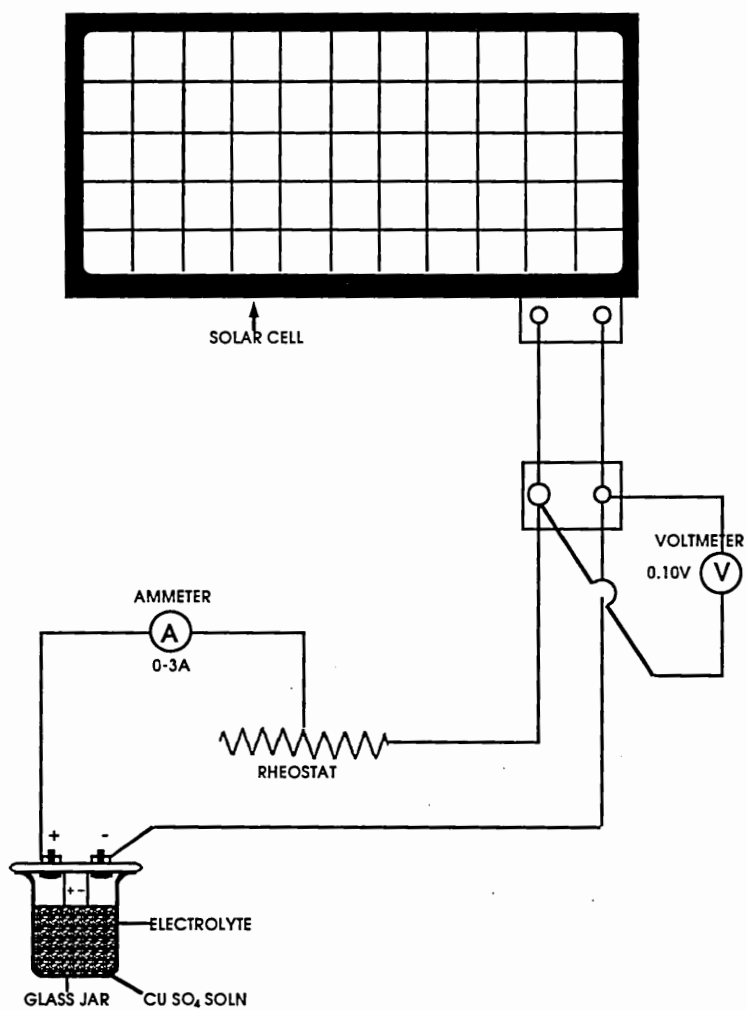


FIG 2: EFFECT OF CHANGE IN CURRENT DENSITY ON THE DEPOSITION OF CU POWDER

0.5A, 1A, 1.5A, 2A and 2.5A, with the help of rheostat introduced in the circuit used for above mentioned two sets of experiments Fig. 2. All other concerned factors were kept constant, throughout the experiment. Current density at cathode (area sq. in) was calculated and copper powder collected from cathode at each current density was dried and weighed. The results of this set of the experiments are given in table-3.

Alloy powder.

The electrolytic process of powder production has not been confined to the manufacture of powder of pure metals but also Alloy powders have been effectively produced by electrodeposition, with simultaneous deposition of two metals. We have produced electrolytic Cu-Ni powder by following the above mentioned technique and depositing Nickle on copper powder. Compsite metal powders, consisting of metal particles of one kind enveloped by the coats of another metal or non-metal e.g. Cu- Ag, Cu - graphite, Ni - Fe, Cu-zn, Cu-Sn and many other metals, can be produced by this technique.

RESULTS

Mathematical

Mathematically the weight of the metal deposited on the cathode during electrolysis, can be calculated by finding out the amount of the charge that should be passed through the solution to deposit one gram atomic weight of the substance. The gram atomic weight of copper is 63.54 gram as its atomic weight is 63.54. We know that number of atoms present in one gram atomic weight of substance is equal to Avogadro's number, i.e. 6.02×10^{23} . If one atom transfers a charge of ne as it is deposited on the plate as one gram atomic weight of the substance is deposited on it will be $ne \times 6.02 \times 10^{23}$. Substituting the value of e in coulombs, the amount of the charge comes to be $96500 \times n$ coulombs. Thus

the charge transported in depositing one gram atomic weight of a monovalent ($n=1$) ion is 9600 coulombs.

Amount of copper deposited in 30 minutes electrolysis of Cu SO_4 Soln with one Ampere current can be calculated as follows:

The charge transferred through the electrolyte in 30 minutes:

$$= 1 \times t \quad (1 = 1\text{A}, t = 30 \times 60 \text{ s})$$

$$= 1 \times 30 \times 60$$

$$= 1800 \text{ coulombs}$$

As copper ion is divalent, therefore quantity of charge required to deposit one gram atomic weight of copper i.e. 63.54 gms is 2×96500 coulombs. Then the amount of copper deposited by 1800 coulombs of charge is

$$\frac{63.54}{2 \times 96500} \times 1800 = 0.5926 \text{ gms}$$

Amount of copper deposited during electrolysis with different amount of current was calculated by the above mentioned method.

Experimental

Generally it has been confirmed that during electrolysis amount of the copper deposited depends upon:

1. The quantity of the current passing through the electrolyte i.e. with the increase of current, the weight of the powder depositing increases proportionally in a solar cell, the current produced depends upon the temperature of the sun rays falling on the cell, angle of rays, angle of reflection and ambient conditions e.g. speed of air blowing.
2. Concentration, temperature and rate of circulation of electrolyte. With the increase of all these three factors the weight of electro-deposit increases.

3. Size, type and distance between anode and cathode.

Structural

The structure of electrolytic powder particles is characteristically crystalline, their shape is generally dendritic of fern like, but many types of powders especially electrolytic iron, consists of particles of substantially solid nodular structure. Each particle usually contains several individual grains, often spreading from the centre of the circumference.

Copper powder

The particle shape of electrolytic copper powder varies from equiaxed, coarse particles of high apparent density to irregularly shaped, fine particles of low apparent density.

Nickel powder

Dendritic structure

Iron powder

Irregular granular structure

Chemical analysis

Copper Powder	Copper	99.5 %	Impurities 0.2 % max.
	Oxygen	0.35 % max.	Apparent density 2.2 - 2.5 gm/cm ³

mineral Sulphate	Sulphate	0.01 % max.
------------------	----------	-------------

Nickle Powder	Nickle	99.5 %	Silicon 0.03 % max.
	Iron	0.2 % max.	4.1-4.35 gm/cm ³
	Sulphur	0.03 % max.	

Iron Powder	Iron	97.5 % max.	Phosphorus	0.025 % max.
	Carbon	0.05 % max.	Manganese	0.04 % max.
	Sulphur	0.025 % max.	apparent density	2.35 - 2.75 gm/cm

DISCUSSION

In order to maintain control of the particle size and to prevent fluctuation in the yield, the adequate removal of the powder either continuously or at frequent intervals is of great importance. The effort has, therefore, been made to produce a substantially non-adherent deposit, which either drops to the bottom of the cell or can be readily removed by regular scraping of the cathode. On several other means, involving the use of rotating cathode, rapid circulation of electrolyte and periodic interruption of current.

The electrolyte (Cu SO_4) was acidified by the addition of some drops of H_2SO_4 . It rendered copper deposit more spongy by evolution of H_2 . Some of the other researchers have suggested other organic and inorganic substances in colloidal form for increasing the efficiency of process of electrolysis. Soluble organic agents, such as sugar, glycerin and urea have been recommended by Hard for producing electrolytic iron powder. Drouilly uses glucose in his basic process of producing electrolytic copper powder. In this method fuming of H_2SO_4 with glucose prior to the addition of acid to the electrolyte, eliminates hydrogen evolution at the cathode and improves current efficiency. The colloidal additions are believed to act as crystallization centres favouring the formation of many crystallites instead of a few larger grains.

Hard brittle laminated electrodeposits were also obtained. These were dried and crushed. The powder produced by these electrodeposits was extremely resistant to compacting. Microscopic study showed that they have needle like particles.

The experiments conducted with copper anode and commercial Cu SO_4 as electrolyte, have indicated that some impurities are present in the product even in greater amount than in the anode material. For instance, the oxygen content of electrolytic copper powder is higher as compared with coppers produced by other methods because of the tremendous increase of surface area per unit weight. This

oxygen content in electrolytic powder manifests itself by changing the colour of particles from shining brick red to dark-brown or even black, with an oxygen content of less than 0.5%. Occasionally mixture of Cu_2O and CuO but rarely particles of Cu_4SO_4 solution. If higher content (60 - 90%) of copper oxides refund, these oxides can be reduced by a mixture of gas $\text{H}_2 = 33\%$ $\text{CO} = 32\%$, $\text{CH}_4 = 12\%$, other hydrocarbons = 8%, Balance, N_2 , CO_2 etc = 15%. Oxidised powder is passed on a belt, through a heating chamber at a temporary 400 to 550°C in the presence of reducing gas.

CONCLUSION

The experiments carried out to produce copper and other metals powder by electrolysis of their salts, by using the electric energy generated by the solar cell, have led to the following conclusions:

1. Small amount of electric energy generated by solar cell is sufficient for producing metal powders, by electrolysis of aqueous solution of sulphates of those metals.

This process is feasible and can be applied on the Industrial scale.

2. Variable permitting close control of chemical and physical properties of powder include a composition of the electrolyte (Conc. of metal and its pH) b) temperature of the electrolyte c) rate of circulation of electrolyte d) their distance from each other and f) other agents, specially added to electrolyte.
3. All powders produced electrolytically must after their removal from the cathode or bottom of the electrolytic bath, be subjected to cleaning and drying treatments. The powders must be carefully washed to remove all the smallest amounts of salts left on the surface will cause rapid oxidation upon exposure to air.
4. The most important advantage of powder produced by

Table-1. Effect of temp. of Sun on the wt. of copper powder produced by the electrolysis of Cu-So₄

S.No	Constant	Variable factor/ tem of Sun		Voltage across the plates		Current on load	Wt. of copper produced		Comments
		Time PM	Temp° C	without load Volts	on load Volts		By Calculations gms	By experiments gms	
1.	a: Normality of N Soln = In b: Time of electrolysis = 30 min.	1	44	17	13	2.50	1.4800	1.540	Irregular coarse powder
2.	- do -	2	42.5	16	13	2.40	1.4200	1.400	- do -
3.	- do -	2.30	42	16	10	2.30	1.3600	1.310	- do -
4.	- do -	4	40	15-16	5-6	1.20	0.7110	0.770	- do -
5.	- do -	5	38	14.5	2.5	0.20	0.1100	0.100	- do -
6.	- do -	6	35	13.5	0.5	0.05	0.0296	0.027	- do -

Table-2. Effect of normality of Soln. on the wt. of copper powder produced by the electrolysis of Cu-So4

S.No	Constant factor	Variable factor/normality of Soln. N	Time PM	Temp° C	Voltage across the plates		Current on load	Wt. of copper produced		Comments
					without load Volts	on load Volts		By Calculations gms	By experiments gms	
1.	Time of electrolysis = 15 min.	0.133	1 to 1.15	44-45		13.0	2.5	1.480	1.540	Irregular coarse powder
2.	- do -	0.266	1.22 to 1.37	16-00		13.0	2.4	1.420	1.400	- do -
3.	- do -	0.370	1.40 to 1.55	16-00		10.0	2.3	1.360	1.310	- do -
4.	- do -	0.665	2 to 2.15	15-16		5-6	1.2	0.711	0.770	- do -
5.	- do -	1.330	2.18 to 2.30	14.5		2.5	0.2	0.110	0.100	- do -

Table-3. Effect of current density on the wt. of copper powder produced by the electrolysis of Cu-So₄.

S.No	Constant factor	Variable factor/ Current Density Amp.	Current Density Amp/ft ²	Voltage across the plates		Wt. of copper produced		Comments
				without load Volts	on load Volts	By Calculations gms	By experiments gms	
1.	Normality of Soln = IN Time of electrolysis = 15 min.	0.5	07.2	16.17	7.00	1.480	0.15	fine powder
2.	- do -	1.0	14.4	16.00	6.00		0.27	- do -
3.	- do -	1.5	21.6	- do -	5.60	0.2960	0.41	Irregular coarse powder
4.	- do -	2.0	28.8	- do -	4.56	0.5925	0.60	- do -
5.	- do -	2.5	36.0	- do -	7.50	0.7407	0.70	- do -

Table-4. Particulars of different methods of electrolysis used by different investigators to produce copper powder

S.No	PARTICULARS	KOCHLER (2)	Fitzpatrick & Collaborators (2)	Fisher (2)	Author #
1.	Electrolyte composition	0.5 - 3.5% CuSO ₄ 0.5 - 10% free acid water	CuSO ₄ in lead lined wooden tank	4 % CuSO ₄ 8 % Na ₂ SO ₄ 89 % H ₂ O	Normal soln. of CuSO ₄ in water
2.	Bath temperature	24-38-C	54-C	*	23 - 28° - C
3.	Electrode spacing	3"	*	*	3"
4.	Voltage	2 - 7 V	1.5 V	15.5 V	17 Volts at no load 5-13 volts on load
5.	Cathode current density	70 amp/ft ²	380 A/ft ²	138 A/ft ²	36 Amp/ft ² max.

For electrolysis, the electric energy was taken from solar cell

* not specified by author

electrolysis over most of other kinds of powder is its extra ordinary purity. More over certain advantages of other processes, such as the large measure of control over apparent density, particle size and particle shape made possible by reduction method and equally assured by electrolytic process. However powder obtained by the electrolytic method is generally somewhat harder than that produced by reduction.

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MULTIPHASE TRANSPORT AND PARTICULATE PHENOMENA

VOLUME 3

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Studies Concerning Effective Utilization of Marshes of Rann-of-Kutch, Sindh, Pakistan.

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ABSTRACT

Samples of the mud marshes of Rann-of-Kutch, situated at 100 miles south-east of Hyderabad, Pakistan were taken and analysed at soil Research Laboratory of Agriculture Research Institute Tandoja, Pakistan. According to the soil report the mud has clayey texture and moderate alkaline in nature. Sample of mud flaps from district of JATI contains total N = 0.012% P_2O_5 = 6 to 10.81 ppm K_2O = 252 ppm, organic matters = 0.825%, T.S.S= 2.96% and soils pH is 7.8 to 8.10. Composition of samples from Rahimki Bazaar varies largely and is given in the text.

Mineralogical analysis of the mud has been conducted at Zeal Pak Cement Factory, Hyderabad to know that this kind of marshes may be used as the replacement for the slurry used for manufacturing of cement. Principal mineralogical constituents of these marshes are SiO_2 = 55 to 61.12%, Al_2O_3 = 10.13 to 18.57%, Fe_2O_3 = 1.87 to 5.25% to Lime = 8.46 to 8.76% MgO 1.15 to 2.39% Sulphuric Anhydride 0.55 to 1.92% chlorides = 1.70 - 1.94% (high value).

During magnetic treatment of mud, Lorenze force acts on Mg, Ca^{++} , Ca, ++ Na, + K, + H⁺, SO_3^{2-} , Si_2O^{2-} , OH⁻ radicals and these ions may reach in the state of resonance. Thus, mechanical properties e.g. compression strength and

resistance of abrasion, are considerably increased. These activated clays have extensive application in foundries, as a binder in the moldings sands.

1. **Introduction [5]**

The Great Rann covers an area of about 7,000 sq miles (18,000 sq km) and lies almost entirely within Gujrat State, India, along the border with south of Pakistan. The little Rann of Kutch extends east and south from the Gulf of Kutch and occupies about 2,000 sq miles in Gujrat state.

Originally an extension of the Arabian Sea the Rann of Kutch has been closed off by centuries of silting. During the time of Alexander the Great it was a navigable lake, but it is now, an extensive mud flat, inundated during monsoon seasons.

In 1965, a dispute arose about the boundary line between between India and Pakistan towards the western end of the Great Rann. Fighting broke out in April between the regular forces of both countries, and ended only when Great Britain intervened to secure a cease-fire. On the report of the secretary general of the United Nations, who visited the scene, the dispute was referred to an international tribunal. In 1968 it awarded about 10 percent of the border area to Pakistan and about 90 percent to India; the partition was effected in 1969.

Today, the Rann of Kutch is a dry barren land which turns into swamps after rains, when water brought by River Luni from the East, Puran from the north, and some stream of Kutch from the south fill it up, to the depth of a few feet. The water does not dry till November.

2. **History**

Present Investigations conducted by boring at Wirawah, Nagarpark (Rann of Kutch) have greatly helped in tracing the history of Rann of Kutch. The salts found in ground water

were of the sea origin rather than calcareous nature. From this, it has been concluded that a branch of the Arabian Sea had been extended in the interior of Rajisthan, possibly along the Luni river, upto Panchabordra in the recent times, and probably upto Samber Lake in the pre-historic period. An inland sea described in mahabharata was probably this arm of Sea [11]

The silting of present Rann started in the recent times by both Hakra and Indus flowing into it. At the time of Alexander's conquest, according to Greek writers, the Rann was a shallow sea. When Mahmood Ghaznavi was returning from his march to Somanath and was pursuing a Hindu chief to the islands north-east of Kutch in 1006 A.D., he was told that sea waves would wash away his boats. This clearly shows that the Rann of Kutch was not dry in the early eleventh century. The town of Pari Nagar, a sea port in Nagarparkar Taluka, was destroyed in 1226 A.D. This was the year when Hakra dried up near Umarmkot. This also indicates that the Rann of Kutch was an arm of the sea and was fed by Hakra. Feroz Shah Tughlak crossed the Rann in 1361 A.D. when it was dry. [11]

Balmir was a sea port on Luni River near Nagarparkar in historic times, which shows that in those days Luni was also navigable. Rann of Kutch, at one time a sea creek, was silted up slowly, possible due to silt brought by Luni from Rajisthan, and Hakra and Indus from the north.

3. Coastal Wetlands - Flux of Carbon

Nitrogen and Phosphorus

A variety of physical factors including the geomorphology of the marsh drainage, the areas of marsh and adjacent coastal waters and the magnitude of the water flux appear to be important determinants of whether specific wetlands show significant export or import of dissolved or particulate substances. Two studies appear to have particular relevance at this time in the progression of our understanding of the

dynamics of coastal marshes. Both studies examine the nature and apparent origin of detritus exported from coastal salt marshes. Harris (1980) noted that the suspended particulates collected from ebb tide waters in a Florida coastal marsh are composed not of vascular plant fragments but of amorphous aggregates, derived primarily from organic films produced by benthic microflora. The second study, by Haines (1977), examined the carbon isotope composition of seston in Georgia estuaries and concluded that this material is derived not from the vascular plants of marshes but from algal production in the estuaries. This implies a minor contribution of marsh particulates to the organic carbon of coastal waters and suggested that important outflux may be in dissolved form.

Materials are brought to and removed from wetlands largely as a function of water movement, and the pattern of water movement is the primary determinant of the direction and thrust of nutrient flux in these complex systems. Nutrient discharge from the land tends to be correlated with water discharge (Brehmer, 1958; Kevern, 1961; Vannote, 1961), and in most wetlands the major portion of the annual nutrient load enters into the spring.

The general pattern of reduced water discharge during the summer results in increased detention of water in wetlands during this period. However, water seldom runs through wetlands in a uniform manner, but is channeled such that the mean detention time of the water varies greatly throughout the wetland. In those areas where the detention time is increased, the water temperature rises and pH increases because of changes in the carbonate-bicarbonate equilibrium caused by both the warming of the water and increased photosynthetic extraction of carbon dioxide from the alkalinity.

Sediments, and particularly inorganic sediments, play significant roles in the ability of wetlands to retain phosphorus and heavy metals. The equilibrium adsorption

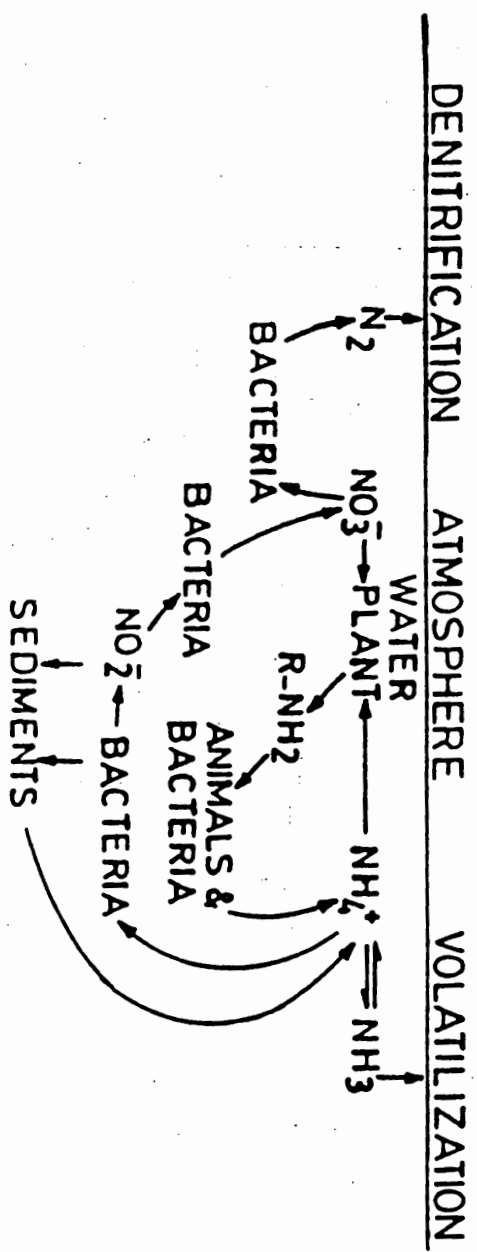


FIG. 1 NITROGEN CYCLE IN AQUATIC SYSTEMS

capacity of sediments for such materials varies as an interactive function of both sediment type and chemical characteristics of the water. An example of these interactions is seen in the equilibrium phosphorus adsorption capacity of three different clays shown by Edzwald (1977) to vary as a function of clay type and water. Edzwald concluded that the type and amount of the free metal content of the clay played a major role in determining its phosphorus adsorption potential.

Nutrients cycle in wetlands as elsewhere as a function of biotic activity limited by interacting physical, chemical and biological factors. On the board scale, macrophyte in wetlands varies as a function of light, temperature and nutrient availability, while the remainder of the community is limited by the production and introduction of organic carbon. Within these broad limits, however, biotic interaction can be alter the entire ecological structure of shallow water systems. Nutrient cycles in wetlands are contolled largely by chemical thermodynamics and mediated by biotic activity relative to the inputs of water and material. Seasonal variations in inputs of both water and materials in north temperature wetlands coupled with seasonal variation in light and temperature ensure marked seasonal variation in the nutrient dynamics of wetlands. Samples taken during the summer indicate that the wetland is a sink for many nutrients.

Samples taken during the summer indicate that the wetland is a sink for many nutrients, while samples collected during the early spring would suggest that the wetland is a nutrient source. Sometimes even in a single season, there will be a large variability in nutrient flux in most wetlands. For example, during the summer there is tremendous spatial variation in nutrient dynamics withing wetlands governed largely by interactions between plant photosynthesis and hydrology. The reasons for such variation can be illustrated with the effects on the nitrogen cycle caused by interactions

between plant activity and the hydrology (Fig. 1)

Ammonification is the process whereby nitrogenous compounds in plant and animal tissues are decomposed to produce ammonia which is changed by nitrification into nitrite, and then into nitrate, each stage being accomplished by specific micro organisms. The formation of ammonia is accomplished by heterotrophic bacteria but the two other stages are brought about by autotrophic bacteria. Ammonia is oxidized by *Nitrobacter*. These processes require aerobic conditions; if the soil is waterlogged for any length of time, the nitrogenous compounds are reduced by denitrification to nitrogen which is lost to the atmosphere.

Nitrogen fixation is the process during which soil bacteria take up nitrogen from the soil atmosphere to form their body protein. The organisms include *Azotobacter*, *Clostridium pasteurianum* and *Beijerinckia* which upon death enter the nitrogen cycle and are decomposed to form nitrate for plant uptake.

There are also a number of bacteria which enter the roots of certain plants, particularly members of the Leguminosae. There, they multiply, form nodules and fix atmospheric nitrogen, which then passes into the conducting system of the plant as an essential element.

Bowden (1984) recently estimated the annual net ammonium production rate of a freshwater tidal marsh in Massachusetts to be about $1.7 \text{ mol N/m}^2 \text{ /Yr}$ ($33.8 \text{ g N/M}^2 \text{ / hr}$) in the top 10 cm of sediment. King (1979), reporting on a series of two meter deep ponds in Michigan dominated by submerged macrophytes and charged with a good quality secondary effluent, noted a 97 percent nitrogen removal in a detention time of 120 days.

4. Experimental:

4.1 Soil Analysis

Samples of marshes from Jati coastal areas (Musafirkhana) were taken from different areas and depths. They were mixed in equal ratios.

Samples were also taken from sandy, clayey and gravelled strata of dried mud flaps near coastal areas of Rahimki Bazar.

All these samples were packed in plastic envelopes tagged and delivered to Soil Research Lab., for analysis.

4.2 Mineralogical Analysis

Contents of minerals e.g. SiO_2 , Al_2O_3 , Fe_3O_4 , CaO , MgO , were also determined in the samples of marshes and dried mud flaps of Jati and Rahimki Bazar.

4.3 X-Ray analysis

All the above mentioned samples were analysed by X-ray diffraction.

5. Results

5.1 Soil Analysis

Results of soil analysis are given in table 2 & 3. According to the Soil report, the mud from Jati has clayey texture and moderately alkaline in nature, while contents of N , P_2O_5 and K_2O in four samples from Rahimkibazar varies largely and are given in table 2. Texture is reported to be silty clay, Fine gravel, very fine sandy loam and clay loam.

Content of sand, silt and clay in lower Sindh plain at Badin adjacent to the Rahimkibazar is given in table 4 [14]. Percentages of these constituents in soil of Tharparkar desert are given in table 5.

5.2 Mineralogical analysis

Mineralogical analysis of two representative samples of Rahimkibazar and Jati are given in table 6.

5.3 X-ray analysis

X-ray diffraction shows that all samples from

Rahimkibazar and Jati contain mainly quartz, kaolinite and wustite. All these samples are identical except silicious sample of Rahimkibazar (A-1) which contains quartz in larger quantity as compared to other samples. These samples also contain halloysite, and calcite, while pepidocrocite, FeO (OH) is also suspected.

Table 1. Some of Typical marshes of the World [5]

No.	COUNTRY/ LOCATION	SEA/RIVER/ DELTA	EFFECTIVE UTILIZATION
1.	Camargue	Rhone delta	Bird sanctuaries
2.	Spain	Guadalquivin	-- do --
3.	Romania	At mouth of Danube	-- do --
4.	Egypt	Nile delta	
5.	Iraq	Tigris - Euphates	
6.	Vietnam	Mekony delta	
7.	Brazil	Amazon delta	
8.	U.S.A	Mississippi river delta	
9.	Poland/Russia Boundry	Pripet marshes	Natural boundry between USSR & Pola
10.	Sudan (Southern part)	Papers marshes if upper Nile	
11.	Bostmana (Kalhori desert)	Okavango marshes	
12.	Florida (Everglades)		
13.	U.S.A (Utah)	Great salt lake	

Conclusion

1. The reaserach have shown that wetlands have a very high economic value. Salt marshes are believed to serve

as a nursery ground for over half the species of commercially important fishes in the south-eastern United States. The rate of wetlands which are being destroyed is illustrated in the following example that nearly 30,000 acres of salt marsh once present in connecticut, less than half remains today.

2. A very important characteristic of wetlands is their ability to remove inorganic nitrogen compounds and metals from ground water polluted by land sources. Most of the removal is probably achieved through adsorption on clay-sized particles. Some of the nitrogen compounds trapped in the sediment are decomposed by denitrifying bacteria, releasing the nitrogen to the atmosphere as nitrogen gas. Much of the remaining compounds is used for plant production in this environment, which is one of the most productive in the world. With the death of the plants, the organic nitrogen compounds are either incorporated into the sediment and converted to peat or are broken up and become food for bacteria, fungi or detritus-feeding shell and fin fish. [12]

Table 2. Soil analysis of sample from JATI

1. T.S.S. %	=	2.96
2. Soil pH	=	8.10 (moderate alkaline)
3. Texture	=	Clayey
4. Organic Matters %	=	0.833
5. Available Nitrogen %	=	0.0466
6. Available Phosphorus	=	10.81 PPm.
7. Available Potassium	=	252 PPm

Table-3. Soil Analysis of the samples taken from different zones of Rann-of-Kutch, Sindh*

S. No.	ZONE OF RANN- OF-KUTCH, Sind.	SALINITY %	pH	ORGANIC MATTER %	NITROGEN %	PHOSPHOR- OUS AVAIL- ABLE, Pp.m.	POTA- SIUM Pp.m.	TEXTURE
1.	Rahimki-bazar	3.20	7.81	0.825	0.0412	6.0	252	Silty clay
2.	--- do ---	0.304	7.78	0.238	0.0119	2.2	120	Finally gravel
3.	--- do ---	1.04	7.93	0.428	0.0214	2.4	100	Very fine sandy loam.
4.	--- do ---	2.16	7.37	0.1333	0.0666	4.4	380	Clay loam.

* Conducted in Soil Research Lab., Agriculture Research Institute,
Tandojam, Pakistan.

Table-4.
Analysis of Soil from Lower Sindh**

LANDFORM	LOCATION	Analysis (before re-Analysis (after removal of calcium carbonate & organic matter & before dispersal of mineral fraction)						Approx. per-centage of cal-Clay Agg. in untreated Sample.
		Sand%	Silt%	Clay%	Sand%	Silt%	Clay%	
Cover Flood Plain	Lower Sindh Plain at Badin	13.2	73.2	14.4	14.6	59.8	25.6	14.5
								43.8
Note:		Sand particles have diameters between 0.05 mm and 2mm. Silt particles have diameters between 0.002mm and 0.05mm. Clay particles have diameters less than 0.002 mm.						

* Source: Colombo Plan Report. p.47 [14]

** Place of sampling.

Table-5.
Analysis of Soil: Tharparkar Desert

	Surface Percentage	Subsoil Percentage
Clay and finest silt	5.23	10.71
Fine Silt	0.74	1.44
Medium Silt	0.40	0.26
Coarse Silt	1.93	2.24
Fine Sand	30.41	25.12
Coarse Sand	61.29	50.23

3. The soil of the Indus Delta are made up of sands, silts and clays. Insoluble silicates in sand and silt form more than 66 percent of the constituent, the remaining 34 percent are alumina, ferric oxide, salt, manganese and other minerals. Different places have different surface texture. Generally, the areas of high relief, like the natural lakes or overbank deposits, are characterized by medium textured soils, while area of comparatively lower relief have moderately heavy-textured soils. The finer materials are carried away by the river into the tidal areas, where they are either deposited as mudflat material, or carried to the sea. [14]

4. Composition of clay and slurry used by Zeal Pak Cement Factory, Hyderabad, Pakistan, for manufacturing of cement was compared with mud of the marshes from Rann-of-Kutch.

<u>Zeal Pak</u>	<u>Zeal Pak</u>	<u>Rann of Kutch</u>
		<u>(Rahim-ki-Bazar)</u>
<u>Clay</u>	<u>Slurry</u>	
SiO ₂ = 55-60 %	SiO ₂ = 13-14 %	SiO ₂ = 55-80 %
Fe ₂ O ₃ = 6-10 %	Fe ₂ O ₃ = 2-2.5 %	Fe ₂ O ₃ = 0.5 to 5.25 %

Table-6. Mineralogical analysis of Mud collected from different zones of Rann-of-Kutch. *

		RAHIMKI BAZAR		JATI	
		Silicious Sample A - 1	Clayey Sample A - 2	Silicious Sample B - 1	Clayey Sample B - 2
Loss on Ignition	L.O.I.	8.10	7.52	7.00	5.38
Silica	SiO ₂	80.57	55.97	68.74	61.12
Alumina	Al ₂ O ₃	5.10	18.57	10.13	14.80
Ferric Oxide	Fe ₃ O ₄	0.50	5.25	1.87	3.62
Lime	CaO	5.74	8.46	8.36	8.76
Magnesia	Mgo	1.30	2.39	1.81	1.15
Sulphuric Anhydride	So ₃	Traces	0.89	1.92	0.55
Chloride	Cl ⁻	1.68	1.79	1.70	1.94

* Conducted in Chemical Lab. of Zeal Pak Cement Factory, Hyderabad, Pakistan.

$\text{Al}_2\text{O}_3 = 15-20 \%$ $\text{Al}_2\text{O}_3 = 3.5 - 4.5 \%$ $\text{Al}_2\text{O}_3 = 5.10 - 18.57 \%$

$\text{CaO} = 7.4 \%$ $\text{CaO} = 42 - 43 \%$ $\text{CaO} = 5.79 - 8.76 \%$

$\text{MgO} = 1.42 \%$ $\text{MgO} = 1.15 - 2.34 \%$

(Sulphuric Anhydride = 0.41 % (Sulphuric Anhydride = 0.55 - 1.92 %

By comparing the composition of clays of Zeal-Pak and Rann-of-Kutch zones, it is clear that compositions of both of the clays are nearby.

Future Research

This type of the clays is also useful for manufacturing activated bentonite, which is extensively utilized in metal casting, as a bonding material for making sand moulds. When clays of above mentioned composition are treated magnetically the Lorentz force acts on Mg , ^{++}Na , $^{+}$, K , ^{+}H , SiO_2 , Si_2O_5 and OH^- radicals [4] Further research in this domain will open a channel for manufacturing of activated bentonite from the mud of marshes.

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HEAVY METALS IN SINDH WATERS

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ABSTRACT

Much of the research work has been carried out by domestic and foreigner investigators on the pathogenic organisms in the drinking water. However, R & D work on estimation of traces of heavy toxic metals in water samples from Sindh River is very limited: Authors have detected and estimated the quantity of Fe, Cd, Se, Cu & Mn in samples of Sindh River waters and it was concluded that quantity of these metals was within the tolerable range. However, keeping in the view the intoxicating effect of these elements on primary health, when their percentages cross the admissible range, the effect, of these elements in creating non infectious diseases, is discussed in detail. In the conclusion, researches concerning separation of sludges, heavy metals and intoxicating inorganic materials are mentioned briefly.

INTRODUCTION [5]

The use of polluted water for drinking and bathing is one of the principal pathways for infectious diseases that kill millions and sicken more than a billion people each year. Diseases such as typhoid and cholera are carried in infected drinking water, others are spread when people wash themselves in contaminated water. Because of their effect on human welfare and economic growth, deficient water supplies and sanitation pose the most serious environmental problems that face developing countries today. We consider first the consequences for health.

The direct impact of waterborne diseases is huge, especially for children and the poor (who are most at risk). Unsafe water is implicated in many cases of diarrheal diseases, which as a group, kill more than 3 million people, mostly children, and cause about 900 million episodes of illness each year. At any one time more than 900 million people are afflicted with roundworm infection and 200 million with schistosomiasis. Many of these conditions have large

indirect health effects-frequent diarrhea, for instance, can leave a child vulnerable to illness and death from other causes.

A key question is what the reduction in burden of disease and death that will be if water and sanitation are improved. This is not a simple question to answer, on which all epidemiologists agree. Too little is known about how risks and diseases are distributed and interact with each other, and uncertainly remains over the extent to which modest changes in infrastructure account for long run health improvements. But some impression can be gained from a recent comprehensive review by the U. S. Agency for International Development (USAID), which summarized the findings from about 100 studies of the health impact on improvements in water supplies and sanitation. Most of the interventions studied were improvements in the quality or availability of water or in the disposal of excreta. The review showed that the effects of these improvements are large, with median reductions ranging from 22 percent for diarrhea to 76 percent for guinea worm. It also showed that environmental improvements have a greater impact on mortality than on illness, with median reductions of 60 percent in deaths from diarrheal diseases. A companion WHO analysis of the largest group of health impact studies-those on the effect of water and sanitation on diarrheal diseases-suggest that the effects of making several kinds of improvements at the same time (say in the quality and availability of water) are roughly additive. Project experience shows that the gains are reinforced by educating mothers and improving hygiene.

Taking these studies as a guideline, it is possible to make a rough estimate of the effects of providing access to safe water and adequate sanitation to all who currently lack it. If the health risks of these people were reduced by the levels almost min 25% then there would be:

2 million fewer deaths from diarrhea each year among children under five years of age (as an indication of

magnitudes, about 10 million infants die each year in developing countries from all causes)

- 200 million fewer episodes of diarrheal illness annually.
- 300 million fewer people with roundworm infection.
- 150 million fewer people with schistosomiasis.
- 2 million fewer people infected with guinea worm.

EXPERIMENTAL

2.1 Sample of waters.

Water samples were concentrated, two liters of water samples were filtered and evaporated to dryness and readissolved in 2N HNO_3 and volume made upto 50 ml in volumetric flask and used as stock solution.

The solution was atomized in air acetylene flame for Cu, Pb, Cd, Ni & Iron.

A series of standard solutions of each cation, in the range of unknown samples, were simultaneously tried or atomic absorption spectrophotometer Hilach Model 180-50, and calibration curve obtained for concentration VS absorbance data, was statistically analysed, using straight line, by least square method.

2.2 Results

The results of different samples of water from Sindh River at Kotri Barrage, (Water Treatment Plant, Hyderabad) are given in table: 1 (S_1 denotes for Lagoon water, while S_2 & S_3 , respectively for drinking & Alum treated waters).

Analyses have shown that quantity of Fe, Cu, Pb, Cd, Se & Mn in drinking water sample and other samples is within the admissible range.

Table:- Determination of trace metals in the water samples of Sindh River.

S. No.	Metal Determined	Quantity in samples Mg/Litre			Ad-Missible Range for drinking water Mg/Litre WHO standard	Remarks
		S ₁	S ₂	S ₃		
1.	Fe	0.4329	0.215	0.274	1.0	All samples are within the tolerable range.
2.	Cu	0.09299	0.04299	0.0540	1.5	-do-
3.	Pb	0.0093	0.0059	0.005	0.1	-do-
4.	Cd	0.00052	N.D	N.D	0.01	-do-
5.	Se	0.0485	0.0054	0.005	0.01	-do-
6.	Mn	0.45	0.406	0.21138	0.5	-do-

Key

S₁ = Lagoon water

S₂ = Drinking water

S₃ = Alum treated water

N.D. = Not detectable.

3. HEAVY METALS & OTHER INORGANIC CONTAMINANTS [1] [3] [6]

Arsenic is a by-product of copper and lead melting and roasting of gold, silver and cobalt ores. It is primarily an airborne pollutant, but it can contaminate bodies of water and accumulate in fish. It is also a component of some agricultural insecticides and fungicides. The main health effect is arsenic poisoning of workers in the gold mining industry and of agricultural workers who handle materials containing arsenic. One symptom is the paralysis of the lower limbs, although acute poisoning includes gastric and intestinal upsets. It is considered to be a potential carcinogen contributing to occupationally related lung cancer.

Asbestos is used for the production of asbestoscement floor tiles, brake linings and gaskets, and the manufacture of fireproof linings and textiles. Those working directly in the mining of the mineral and the manufacture of its products suffer the most adverse effects, but consumers are also regularly exposed to asbestos due to the great variety of asbestos products in daily use. In the form of fibers, asbestos is an airborne pollutant, and inhalation of these fibers over an extended period of time can result in asbestos pneumoconiosis, or asbestosis which is a severe scarring of the lungs. In addition of forcing the heart to work hard, this scarring can complicate other existing respiratory diseases. Fatalities from asbestosis are often the cardiac failure. Asbestos is generally regarded as a carcinogen. Lung cancer among people exposed to asbestos 'dust' occurs with a frequency of more than twice that of the general population.

This has led to public concern over the presence of fibers in air from products made with the mineral. Asbestos fibers can also be present in water supplies, if asbestos products are manufactured nearby, and in processed beverages (soft drinks beer and wine) when asbestos filters are used for removing impurities. There is no evidence that ingestion of asbestos fibers is harmful to humans.

Cadmium, a metal toxic to most species, is released into the environment from industries (electroplaters, battery producers, etc) in sufficient quantities to warrant its classification as a pollutant. As a result of these industrial effluents, it is commonly found in municipal sewage sludges at concentration high that the normal background values. The most significant health effects are found in workers subjected to cadmium fumes. Exposure to the fumes, which are suspected to be carcinogenic, can result in degeneration of the joints. Cadmium is taken up at all levels of the food chain, from micro organisms to human. Human consumption of leafy vegetables fish, shellfish, and drinking water is the usual method by which cadmium poisoning between 1962 and 1977 as a result of people eating food contaminated with cadimium. The source of the metal was traced to runoff from mine tailings.

Lead may be present in the food and water we consume and in the air we breathe. The combustion of leaded gasoline is the largest source of lead pollution in the atmosphere. Raw water supplies can be contaminated by lead from the discharge of sewage treatment plants and from agricultural runoff. Water distribution systems may also contain high concentrations of lead due to the use of lead joints in water mains and lead pipes for water lines inside buildings, which were common at one time. The problem is more severe with soft water, which has a greater tendency to dissolve lead than hard water does. Lead accumulate slowly in the body. The initial symptoms of lead poisoning are stomach-ache and physical weekness. The final stage may lead to a collapse of the central nervous system. Lead poisoning appears to be most prevalent in children, due to partially to their greater capacity to absorb lead and their tendency, at early ages, to chew on cribs, toys, etc, that may have been painted with a lead-base paint.

Mercury poison example is the Minimata Bay disaster in Japan. Inorganic mercury compounds are used in the

production of electrical components such as switches, and in the chlor-alkali industry for the production of chlorine and sodium hydroxide, organic mercury compounds are used as slimicides and fungicides in the pulp and paper industry and in agriculture.

Poisoning by methyl mercury (the most common organic compound) is characterized by numbness, speech impairment, and loss of motor coordination progressing to paralysis, deformity, coma and death. Poisoning by inorganic mercury (parcitary vapours) results in damage to the central nervous system and possible psychotic disorders, Exposure to mercury can be either through the food chain or in the work place.

A steady diet of seal food from a mercury-contaminated source poses a substantial risk to the consumer. Mercury released in past decade is still present in botom sediments of lakes and rivers, and will continue to be a source of pollution for the near future.

Nitrates and Nitrites derived from the excessive use of fertilizers, can result in significant nitrate pollution of surface water and groundwater. Manuer from livestock, foodlots, and poultry operations also has a high nitrate content. The human body is capable of reducing nitrates to nitrites in the digestive system. There are two distinct threats to human health from nitrities. First, nitrities can oxidize the hemoglobin (containing Fe^{+2}), to methemoglobin (containing Fe^{+3}), which is incapable of transporting oxygen in the blood stream. This illness, known as methemoglobinemia or blue baby disease, is especially harmful to infants since, they are particularly susceptible to asyphyxiation by methemoglobine-mia.

Second, nitries can combine with various amines in the gastrointestinal tract to form nitroamines, many of which are known to be carcinogenic. Concern has been expressed about the use of nitrites in cured meats (bacon, prepared meats, hot dogs, etc.) to retard bacterial growth to prevent botulism.

Unfortunately any suitable chemical replacement for nitrites has not yet been found.

Radium and Radioactivity in water:- The need for knowledge concerning radioactivity in water, its measurement, its physiological effects, and methods for its reduction is increasing in importance, because of the increase in the use of radioactive isotopes in medicine, agriculture and in industry, Knowledge of radiological terms and units is essential. The significance of the concentration and the effects of alpha and beta particles and of gamma and X-rays, should be understood. Methods for the measurement of radioactivity in water are described by Setter.

The radium (Ra^{226}) content of natural surface and ground water is reported by Love as varying between 0.36 and 3.90×10^{-12} g per liter, with a medium of 70 μc per litre in all streams.

The American Water Works Association points out that the tolerance limit for radium is not now a factor in the quality of public water supplies, since at the highest concentration of radium in waters in the United States it would be necessary for an individual to drink 2,180 gal per day to obtain a minimum harmful dose as prescribed in medical practice.

The maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and water have been established for occupational exposure by the National Committee on Radiation Protection. The radioactivity of most natural waters is far below the maximum permissible concentrations.

Levels of radioactivity permissible in water supplies. Maximum permissible concentration for continuous exposure beta, gamma, or alpha emitter 10^{-7} μc (micro microcurie) per millilitre of water.

Emergency level permissible for temporary use immediately following an atomic explosions: Beta-gamma

In general the problem of radioactivity in natural waters is not acute and the probability of the contamination of reservoirs or water supplies by atomic bombs or atomic wastes does not seem acute, Thomas States that "the small additional exposure from nuclear weapons testing programmes in the United Staes does not constitute a health hazard".

Selenium. Selenium, like arsenic, is found in water supplies. It is usually present in insignificant concentrations, but waters with more than about 0.05 ppm of selenium should not be used for a public water supply.

Silica. Silica is present in many natural waters in concentrations between 2 and 60 ppm and to a maximum of over 110 ppm. It has not sanitary significance at these concentrations, but it is objectionable because of the scale formed in steam boilers.

Silver. Concentrations of compounds of silver in natural waters are insignificant. Even the high figure of 0.2 ppm reported in the Denver water supply has no effect on the potability of the water.

Table 2. Summarizes the effect of heavy metals & other inorganic contaminants on health, while tables 3-6 show the admissible ranges of contaminants in different types of waters. For Comparison analysis of commonly used water manufactured by PCSIR is given in table 7.

For comparison, the researches recently carried out by Din M. Sheikh and collaborators [7] on water from Thar district Sindh are also mentioned briefly. This study was conducted on water quality of daily use from Tharparkar district and correlated with multiple health problems affecting Thar population. The pH of the water remains alkaline (7.7-11.5 in some cases even upto 11), thus burdening the kidney management. In present study high concentration of sodium, potassium, calcium and fluoride was observed, causing fluorosis and osteofluorosis. Besides that 60-90% people were also suffering from tuberculosis, asthma and anemia.

Table: Common Inorganic Contaminants causing noninfectious diseases

Inorganic contaminant	Major source	Sphere most affected	Primary health effects
Arsenic	-- Ore smelting, refining -- Pesticides	-- Air, water	-- Arsenic poisoning (gastrointestinal disorders, lower limb paralysis)
Asbestos	-- Heat-flame- resistance applications	-- Air	-- Asbestosis (scarring of lung) -- Carcinogen
Cadmium	-- Electroplaters, battery manufactures	-- Air, food, water	-- Cadmium fumes, joint pain, lung, kidney disease -- Possibly carcinogenic, teratogenic
Lead	-- Leaded gasoline, batteries -- Solder, radiation shielding	-- Air, food, water	-- Impairs nervous system, red blood cell synthesis -- Depends on exposure
Mercury	-- <i>Inorganic form</i> Electrical goods Chlor-alkali industry -- <i>Organic form</i> Slimeicides Fungicides	-- Water, food	-- <i>Inorganic</i> : disorders of central nervous system, possible psychoses -- <i>Organic</i> : numbness, impaired speech, paralysis, deformity, death.
Nitrates/ Nitrites	-- Nitrates: agricultural runoff -- Nitrites: meat preservatives	-- Food, water	-- Nitrates + amines (in body) yield carcinogenic nitrosamines -- Nitrates can cause methemoglobinemia in infants.
Sulphur Dioxide	-- Combustion of sulphur containing fuels	-- Air	-- Irritation of respiratory system -- Precursor of acid rain, which is widely destructive.
Particulates	-- Smoke from combustion -- Dust, pollens, etc	-- Air	-- Can lead to cardiac, respiratory ailments (emphysema, bronchitis) -- Health effects more noticeable if particulates are in combination with other pollutants (e.g. SO ₂)

activity for 10-day use, safe concentration $3.5 \times 10^{-3} \mu\text{C}$ per ml, acceptable risk, 9×10^{-2} per ml. For 30-day use safe concentration is $1.1 \times 10^{-3} \mu\text{C}$ per ml acceptable risk is 3×10^{-2} .

Alpha activity for 10-day use, safe $2 \times 10^{-4} \mu\text{C}$ per ml; acceptable risk $5 \times 10^{-3} \mu\text{C}$ per ml. For 30-day use, 6.7×10^{-5} per ml; and acceptable risk, $1.7 \times 10^{-2} \mu\text{C}$ per ml.

Table-3

CHEMICAL CHARACTERISTICS.

Drinking water should not contain impurities in hazardous concentration.

Substance	Admissible Concentration mg/litre
Lead (Pb)	0.05 maximum
Arsenic (As)	0.05 maximum
Selenium (Se)	0.01 maximum
Chromium (Hexavalent. Cr)	0.05 maximum
Chloride (Cl), taste-producing.	250.00 maximum
Copper (Cu) taste-producing.	1.0 maximum
Fluoride (F)	1.5 maximum
Iron (Fe), colour and taste-producing	0.3 maximum
Manganese (Mn) colour and taste-producing	0.05 maximum
Phenol. taste-producing	0.001 maximum
Zinc (Zn) taste-producing	5.0 maximum
Magnesium (Mg)	125.0 maximum
Sulphate (SO ₄), taste-producing	250.0 maximum
Total dissolved solids	500.0 maximum
Nitrate (NO ₃) producing methemoglobinemia	44.0 maximum

Table-4

INTERNATIONAL STANDARDS FOR DRINKING WATER [6]

Parameter/Metals	Max. Permissible USPH Standard	Level WHO Standard	Mg/L European standard-
Arsenic	0.-05	0.05	-
Boron	1.0	-	100
Calcium	100	100	-
Cadmium	0.01	0.01	-
Chromium (VI)	0.05	0.05	-
Copper	1.0	1.5	25
Chloride	250	500	-
Cyanide	0.05	0.05	-
Iron	0.3	1.0	-
Lead	0.05	0.1	-
Magnesium	30	150	-
Manganese	0.05	0.5	-
Mercury	0.001	0.001	-
Nitrate + Nitrite	10	45	-

Ref. Envir. Chem IInd Edition by Anil Kumar De,p. 328-329

Table-5

**TOLERANCE LIMITS FOR INDUSTRIAL EFFLUENT
DISCHARGE (I.E.D.) into INLAND SURFACE WATER
(RIVERS/STREAMS ETC.) [6]**

S. No.	CHARACTERISTICS	Tolerance Limits (all maximum)
1.	Total suspended solids, mg/lit	100
2.	pH	5.5 to 9.0
3.	Temperature	40 c
4.	B.O.D. for % days at 20 c, mg/lit	30
5.	Oils and grease mg/lit	10
6.	Phenolic compounds	1.0 mg/lit
7.	Cyanides	0.2 mg/lit
8.	Sulphides	2.0 mg/lit
9.	Total residual chlorine	1.0 mg/lit
10.	Fluorides	2.0 mg/lit
11.	Arsenic	0.2 mg/lit
12.	Cadmium (Cd)	2.0 mg/lit
13.	Hexavalent Chromium	0.1 mg/lit
14.	Copper	3.0 mg/lit
15.	Lead	0.1 mg/lit
16.	Mercury	0.01 mg/lit
17.	Nickel	3.0 mg/lit
18.	Selenium	0.05 mg/lit
19.	Zinc	5.0 mg/lit
20.	Ammonical Nitrogen	50 mg/lit
21.	C.O.D.	250 mg/lit

Table-6

**INDUSTRIAL EFFLUENT DISCHARGE IN PUBLIC
SEWER AGE [6]**

S. No.	CHARACTERISTICS	Tolerance Limits (all maximum)
1.	pH	5.5-9.0
2.	Temperature	45 c
3.	Suspended solids, max (max (mg/lit)	900 relaxable to 750
4.	B.O.D. for 5 days at 29° c in mg/lit	500
5.	Oils and grease mg/lit	100
6.	Lead (mg/lit) max	1
7.	Copper ppm.max.	3
8.	Zinc ppm.max.	15
9.	Hexavalent chromium max.	2.0
10	Nickel ppm.max.	2.0
11.	Cyanide ppm. max.	2.0
12.	Phenolic compounds ppm.max.	5.0
13.	Sulphates ppm.max.	1000
14.	Total dissolved solids ppm.max.	2100
15.	Chlorides ppm.max.	600
16.	Boron ppm.max.	2.0
17.	Percent sodium ppm.max.	60
18.	Alpha emitters in µc/ml	10.7
19.	Betaemitters in µc/lcc	10.6
20.	Ammonical Nitrogen as mg/lit	50

Table-7**Table:- Pure Natural Mineral Water****Trade Name: Aba-e-Hayat ***

Chloride	41	Mg/litre
Sulphate	38	
Bicarbonates	159	
Ca	42	
Mg	24	
Na	5	
K	3	
Total dissolved solids	342	

* Manufactured by PCSIR.

4. Fertilizers water and enviromental pollution [4]

Fertilizers should be viewed not only as necessary inputs to alleviate food deficits, poverty and provide employment to the rural population, but also as a too to reduce environmental risks by stablising crops growth, increasing vegetative cover, avoidance of soil erosion and restoration of soil fertility. Optimal use will therefore provide a better environment. However, fertilizers are also source of pollution.

Reverting to environmental risks of over-use, one issue is eutrophication, growth of algae etc, in water bodies due to excess nitrogen and phosphorus, which may have a deterimental impact. Algal biomass growth requires plenty of oxygen, leading finally to anaerobic condition, which in shallow water are fatal for fish stocks.

Another pollution factor reported to be associated with fertilizers use is nitrate pollution of ground water, Fertilizers

nitrogen and organic matter nitrogen are converted by soil microorganisms to inorganic forms, ammonium (NH_4) and nitrate (NO_3). These are highly soluble in soil water and are readily available for crop plant uptake. Excess nitrate may move down with soil water. This is called leaching and can lead to nitrate accumulation in ground water.

Nitrate leaching can be prevented through nitrogen fertilization, according to the needs of the crop. It should also synchronize with crop growth and should be balanced with other essential nutrients. Soil testing is use ful in this respect. However, no such problem can be foreseen in the near future in Pakistan agriculture, where nitrogen use is only half of the recommended requirements. Pakistan uses only 60kg nitrogen per hector corps (against a recommended average of 120) as compared to over 200 kg per hectare use in European and some Asian countries.

The World Health Organization has set a limit of 10 mg of $\text{NO}_3\text{-N}$ in a litre of water. The European community has stipulate approximately the same limit, namely 50 mg nitrate per litre. A disease due to excess nitrate consumption in the bottle-fed babies may result in what is known as blue baby syndrome, but such cases have not been reported since 1970, during which time fertilizer use has multiplied many times. Therefore, these cases may be due to some other reasons. Water is not the only source of nitrates in our diet.

Gaseous emission like nitrous oxide, nitric oxide, ammonia, methane may contribute to global warming. But this can be avoided by adopting best farm management practices, which will also improve fertilizer use efficiency. Heavy metal accumulation in soil can be a serious problem, but this comes mostly from sewerage and city refuse.

5. CONCLUSION

Analysis carried out have shown that quantity of heavy metals in different samples of Sindh waters is within the admissible range. However, in conclusion some of the modern

researches concerning recycling of used impure water and separation of sludge toxic elements & some heavy metals is briefly described:-

1. Companies recycling pollutants or manufacturing products are considered environmentally safe. West Germany's Hankel Corp. is selling phosphate-free detergents. However when released into the waterways, phosphates stimulate the growth of algae, which contaminate the water supply. The procter & Gamble Co. is reducing the amount of molecular chlorine used in the manufacture of its disposable disperse and other items. chlorine, which is used to whiten and purify paper, generally enters into rivers and reservoirs through pulp- and paper-mill waste-water and through groundwater that has spread in from land-fills. [2]

2. Other companies are focusing their efforts on pollutants that have been discharged into bodies of water. One method is recycling sludge- sewage and other industrial water that had picked up sand, grit and other organic material and is then piped to the rivers and seas, At Hoffmann La Roche in Nutley, New Jersey, solvents which are discarded as sludge, are used to run generators and biolers in the cmpany's facilities.

3. In a large sludge-recycling effort, a Massachusetts public water authority has contracted Enviro-Gro Technologies to help clean up Boston Harbour. For years, the Massachusetts Water Resources Authority (MWRA) simply treated sewage and then pumped it into the harbour, where sludge built up and fouled the water. [2]

4. Enviro-Gro will now process the sludge and sell it as fertilizer, with half the revenues gained by MWRA in order to defray the cost of recycling. [2]

5. In a similar effort, Dr. German Muller of the Institute of Sedimetology at the University of Heidelberg, received a Philip Morris Reserach Award for his work in developing technology to extract heavy metals, especially

cadmium, from sludge and other, variety of industrial refuse.

6. Increasingly, broad environmental approaches are taking hold. The Royal Dutch/Shell Group; has commissioned several environmental research projects in Malaysia, including a study of marine life around offshore drilling platforms and another on the biodegradation of crude oil in the Sabah and Sarawak marine environments. The company has also worked to restore coral reefs near Tabangao refinery in the Philippines.

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