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THE EFFECT OF SEAWATER ON THE GRAVITY SEPARATOR TO RECOVER TOTAL INDUSTRIAL MINERALS FROM SIPASURUBILI LEAN PLACER DEPOSIT, ODISHA, INDIA

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Abstract

The present research work discusses the advantages of using seawater to recover industrial minerals present in a lean grade that occurs along the coastal stretch of the Sipasurubili beach sand deposit in Odisha, India. The bulk sample contains 4.7% total industrial minerals (TIM). The present study shows that industrial process ground/surface water could be used to produce a heavy mineral concentrate of 98.2% grade of TIM with 71% recovery could be produced, while the use of seawater produced a TIM product of 98.1% with a recovery of 85% from a gravity separator feed. Considering the industrial importance of placer minerals in modern technology and the higher consumption of process water, seawater can be an alternative for the concentration of lean-grade placer heavy minerals. Therefore, the use of mobile gravity concentrators along the coast for TIM using seawater and subsequent purification of the heavy minerals and the dewatering of saline water from the heavy minerals before sending them to the mineral separation plant is encouraged.

Key words: *dune sand, industrial minerals, TIM, spiral gravity unit, saline water.*

1. Introduction

Gravity concentration plays a major role in the concentration of total heavy minerals. A large amount of literature is available on the selection or use of different types of gravity concentrators [1-6]. In recent years, the use of seawater has emerged as an alternative to freshwater for sustainable industrial operations, and reduces the reliance on fresh water reserves of our planet. The consumption of desalinated or partially desalinated or seawater for mining and mineral beneficiation has been addressed in numerous studies by several authors on different operations. The effect of saline water on mineral flotation [7-9], flotation of coal [10-12], oxidation of coal [13], settling characteristics of coal [14] on copper activation or flotation [15-19] on sphalerite [20], on leaching characteristics of chalcocite [21], flotation of beach sand [22], high-tension separation of ilmenite [23, 24]. The operational records indicated that seawater was used successfully for leaching and flotation processes of copper, zinc, uranium, and iodine minerals. Even though a large amount of seawater is used in mineral processing, it is restricted to flotation and leaching, mostly on sulphide ores (Table 1). Beach placers are a class of heavy minerals transported, concentrated, and deposited by natural processes such as water currents, waves, and tides in sea beaches and are a source of valuable industrial minerals. The raw sand containing these heavy minerals is extracted by dredging and processed by wet gravity concentrators (spiral concentrators) to a desired concentration by separating light minerals. The spiral operates as a gravity concentrator, comprising a helical conduit that has a semi-circular cross-section. At the top of this spiral, feed pulp is introduced, containing solids in the range of 15 to 45 percent and particle sizes from 3 mm to 75 μm. The effective separation of particles with increased specific gravity is realized through a combination of forces that act

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on the particles during their descent in the spiral trough. These forces comprise centrifugal force, gravitational forces, hydrodynamic drag, and the forces of lift and friction. Additionally, the characteristics of the slurry, such as the solids concentration, the feed rate, and the application of wash water, are crucial factors that influence the overall separation process within the spiral apparatus. The scrubbed concentrate is dried and subjected to a series of physico-chemical separation processes, such as electrostatic, magnetic, flotation, gravity tables, to get high-purity mineral products of economic interest, such as monazite, zircon, rutile, sillimanite, garnet, and ilmenite. The process is often complex and involves an array of activities such as raw sand mining, transportation, and multiple beneficiation methods to separate the target minerals. While much research on technological advancement has been carried out on placer heavy minerals in recent years, studies are still scarce with respect to the use of seawater or saline water and its effect on the physico-chemical separation of these minerals. Swamydas et al studied the downstream effect of the use of sea water on gravity concentration and indicated that there is no significant negative effect on the mineral grade and its recovery with reference to titaniferous industrial minerals separated with HTS in a downstream operation [23, 24]. Biswajeet et al. also studied the recovery of total heavy minerals using sea water in the gravity table [25]. To date, there is no evidence on the use of sea water for pre-concentration of beach sand minerals using gravity spirals. Deependra Singh et al. studied the flow sheet development of beach placer minerals of Sipasurubili coast [26]. The primary operational technique for recovering total industrial minerals from coastal sand deposits in India is the utilization of wet spiral units. This method holds considerable industrial significance, especially in the context of beach sand mineral concentration.

It is essential in this context that water scarcity is increasing on earth day by day due to an increase in population, climatic changes, and global warming, as well as stringent regulations on the use of ground or surface water in industries. Since beach and dune placer mining exists all along the coast, bulk concentration of total industrial heavy minerals using seawater spirals is an alternative approach. However, the mining of industrial heavy minerals all along the coast and the pre-concentration of these industrial heavy minerals using seawater spirals is not economical if seawater is also pumped along with the industrial heavy minerals without draining the saline water or desalinated water. In view of this, it is suggested that the use of seawater is limited to pre-concentrating the bulk sand sample, and the pre-concentrated sample is to be cleaned using a cleaner spiral with fresh water.

The present article investigates the effect of freshwater and seawater on the wet gravity concentration (spiral concentrations) to recover total heavy minerals based on the previous studies on beach sand using freshwater [27, 28]. So far, no study has been attempted for the Sipasurubili coastal sand deposit for the use of sea water. This study is essential due to the facts of freshwater scarcity and to provide employment opportunities to the local citizens by using seawater mobile spiral concentrators on site all along the coast for the production of total industrial minerals.

2. Experimental

About 5 tons of bulk beach sand sample was collected along the coastline from Sipasurubili, Puri District, and Odisha, India. The sample collection location map can be seen in Figure 1, from where bulk auger samples were collected for characterization studies. This sample contains 4.7% total industrial minerals (TIM). The bulk representative sample underwent size analysis using Indian standard sieves. Bromoform, an organic liquid with a specific gravity of 2.89, was employed as a separation medium for lighter minerals, lighter heavy industrial minerals, or very heavy industrial minerals. The heavy industrial minerals retrieved from the sink and float analysis were further processed through magnetic separation to extract magnetic minerals, including ilmenite and garnet, while monazite, being paramagnetic, was treated separately. The total magnetic minerals (TMM) were determined via a high-intensity magnetic separator. The effect of water media and seawater media was studied on the Humphreys spiral concentrator using the same bulk (4.7% TIM) sample at different pulp densities, such as 5% to 30%, with a 5% increment. In the present investigation, gravity separation experiments were carried out using a laboratory model spiral concentrator (capacity 1200 kg/h), supplied by M/s. Humphreys Mineral Industries, Inc., Denver, USA, with a 17'' pitch width, is used to recover total industrial minerals.

The spiral gravity concentrate was subjected to cleaning at 15% solids concentration to cleaning with another spiral, which is denoted as a cleaner spiral, and the tailings of the spiral concentrator were subjected to cleaning with another spiral, which is denoted as a scavenging spiral. The experimental details of the cleaner spirals and scavenging spirals, as well as the use of freshwater spirals and seawater spirals, are shown in Figure 2. Grain counting under a standard binocular microscope was employed to perform mineralogical modal analyses. The spiral feed and its products were evaluated through sink-float studies and mineralogical analysis conducted with the binocular microscope.

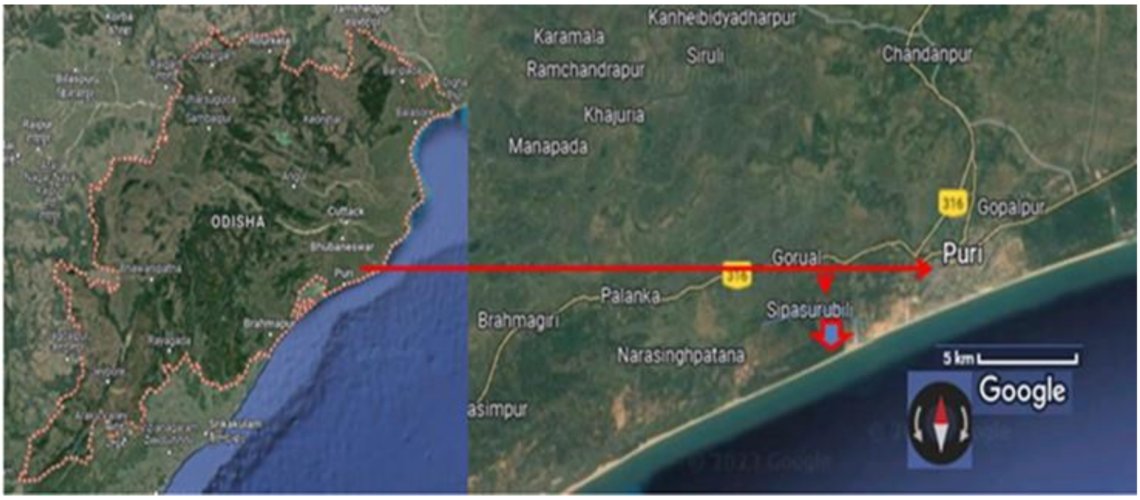


Figure 1 Sample location map (Bulk sample weighing about 5 tons collected)

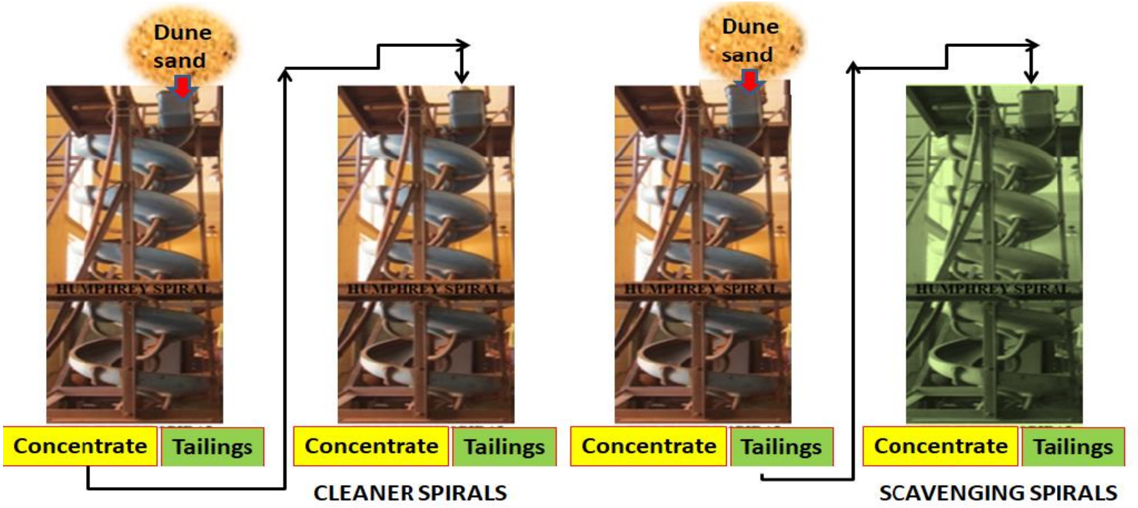


Figure 2 Experimental setup to carry out spiral experiments

3. Results and discussions

3.1. Characterization of the sample

Physical properties such as the TIM, total magnetic minerals (TMM), and d_{80} passing size of the sample are given in Table 1, and the size analysis data are shown in Figure 3. Physical properties of the sample data presented in Table 1 reveal that the sample exhibits a brownish colour with a few black metallic shiny grains, and all are free grains with a 2.89 specific gravity and 4.7% TIM content. It is observed further from the data presented in Table 1 that the d_{80} passing size of this sample is 400 microns and is free from moisture. The Total Magnetic Minerals (TMM) Content in heavies is 2.97%, whereas the Total Non-Magnetic Minerals (TN_MM) Content in heavies is 1.73%, the Very Heavy

Minerals (VHM) content is 3.19%, and the Light Heavy Minerals (LHM) content of this sample is 1.53% (Table 1).

The size analyses of the feed sample and each size sink-float study, as well as the distribution of total heavy minerals present, particularly in every size, are shown in Table 2, indicating that the heavy minerals are more concentrated below 212 microns. It is also seen that the weight percent of each fraction is decreasing significantly below 212-micron size. The feed size analysis and each close size sink float data are also shown in Figure 3, confirming the observations made from the data presented in Table 2.

Table 1 Physical properties of the beach placer dune sample

Details	Physical properties
Color	Brownish sand
Nature	Free grains
Moisture	Free
Bulk Sp. [g]	2.89
d_{80} passing size [µm]	400
TIM [%]	4.7
TMM [%]	2.97
TN_MM [%]	1.73
VHM [%]	3.19
LHM [%]	1.53

Table 2 The grain size analyses of the feed sample and each size sink float study

Size [microns]	Wt. [%]	Sink [%]	TIM [%]
+600	27.92	1.2	0.33
-600+300	40.22	1.5	0.61
-300+212	24.81	4.3	1.06
-212+150	3.43	25.4	0.87
-150+106	2.68	53.5	1.43
-106+90	0.33	66.5	0.22
-90+75	0.53	25.9	0.14
-75	0.08	68.6	0.05
Sum	100.00	-	4.72

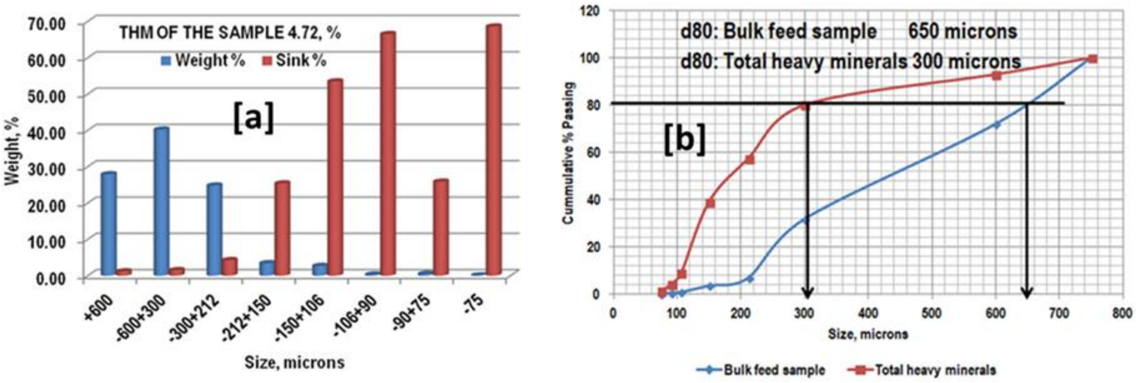


Figure 3 Size analysis of feed and heavy/industrial minerals (a): The size analysis of feed with respect to each size fraction, and (b) d_{80} passing size of the feed sample and the distribution of total heavy (industrial) minerals

Further, it is seen from the d_{80} passing size of the feed sample and the distribution of total heavy minerals in each size shown in Figure 3 that the feed size d_{80} is 650 microns, and the total heavy minerals are 300 microns. The data further confirm that the feed sample, which contains on average 95.25% quartz, is coarser than the total heavy minerals containing ilmenite, rutile, sillimanite, garnet, zircon, and monazite; otherwise, the total heavy minerals, which account for 4.7%, are finer than the quartz. Mineralogical analysis of the bulk feed samples and the TIM samples is shown in Figure 4. The TIM content (4.72%) and the gangue minerals, which majorly contain quartz (95.28%), are shown in Figure 4a, and the percentage of individual heavy minerals such as ilmenite (34.1%), rutile (1.0%), sillimanite (33.5%), garnet (30.4%), zircon (0.7%) and others such as pyriboles (0.3%) present in the total heavy minerals is shown in Figure 4b.

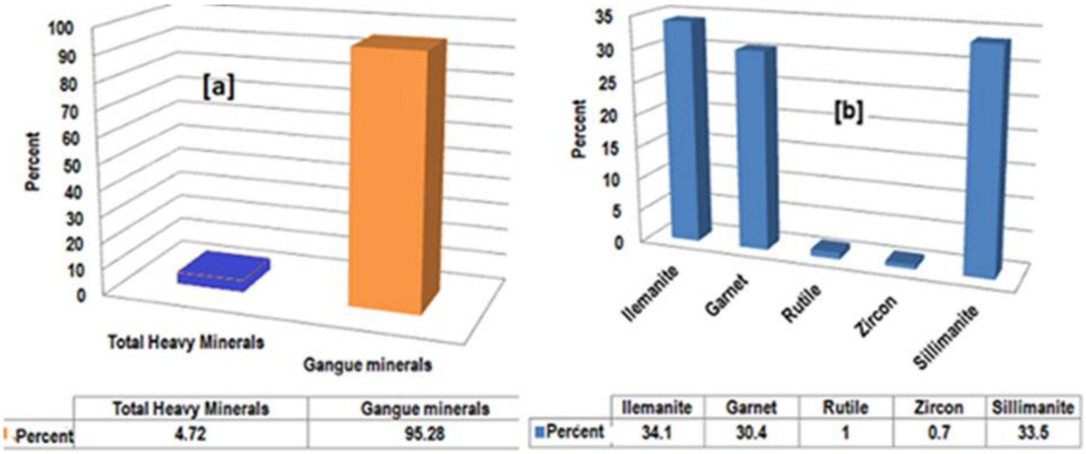


Figure 4 Mineralogical analysis in bulk feed sample and TIM sample (a) TIM and (b) Heavy minerals distribution percent in TIM

3.2. Beneficiation studies

The effects of the concentration criteria on gravity concentration are given in Table 3 to explain the concept of the gravity concentration criterion. It is important to mention here that the wet gravity concentrator is used in two different media, such as freshwater and seawater to study the effects of the medium on the purity and recovery of TIM.

Table 3 Effect of concentration criterion on gravity concentration

Concentration Criterion	Net results
1.25	Possible separation at gravel size
1.50	Difficult separation and applicable commercially up to a size of 2 mm.
1.75	Possibility of separation down to 150 microns
2.00	Logical separation can be possible
2.50	The clean concentrate is obtained with the large tonnage of middling. Getting a low-grade tailing is difficult.
3.00	Gravity Separation is possible at all sizes down to fine sand

The concentration criterion is calculated for all minerals based on the known formula below:

$$d_H - d_m/d_L - dm \quad (1)$$

where: H is the specific gravity of the heavy mineral (monazite 5.10 g/cm^3), L is the specific gravity of the lighter mineral (quartz 2.6 g/cm^3), and m is the specific gravity of the medium (water/sea water).

Here, the specific gravity of the water is 1.0 g/cm^3, and the specific gravity of the sea water is 1.1 g/cm^3.

If this concentration criterion value is below 1.25, practical separation becomes difficult, and direct separation under turbulent conditions is usually uneconomical. Thus, it is essential to know the concentration criterion for the beach sand samples containing different specific gravity-heavy minerals used with different spiral units. The gravity concentration criterion of heavy minerals with reference to quartz (2.6 g/cm^3) and groundwater and seawater as media for the separation of minerals is shown in Table 4.

The data mentioned in Table 4 specify that specific gravity values of all heavy minerals are greater than those of quartz. The highest specific gravity mineral is monazite, 5.10 g/cm^3, and the lowest specific gravity mineral is sillimanite, 3.23 g/cm^3. Accordingly, the concentration criterion for monazite is 2.56, whereas the concentration criterion for sillimanite is 1.39. According to the data presented in Table 3 that the gravity concentration criterion of 2.00 is possible for reasonable separation.

Table 4 Gravity concentration criterion of heavy minerals with reference to quartz (2.6 g/cm^3)

Minerals	Specific gravity	Concentration Criterion [ground water, 1.0 g/cm^3]	Concentration Criterion [sea water, 1.1 g/cm^3]
Ilmenite	4.75	2.34	2.43
Rutile	4.21	2.00	2.07
Garnet	4.25	2.03	2.10
Sillimanite	3.23	1.39	1.42
Zircon	4.69	2.31	2.39
Monazite	5.10	2.56	2.67

3.3. Spiral optimization studies

A few experiments are carried out at different solid concentrations to find out the capacity of the spiral concentrator. The results of the rougher spiral concentrator at different solid concentrations are given in Table 5.

Table 5 Results of rougher spiral concentrator at different solids concentration

Products	Wt [%]	TIM [%]	Rec. [%]
5% Solids			
Concentrate	3.0	55.87	35.5
Tailings	97.0	3.14	74.5
10% Solids			
Concentrate	2.4	68.96	35
Tailings	97.6	3.15	65
15% Solids			
Concentrate	2.8	74.40	45
Tailings	97.2	2.66	55
20% Solids			
Concentrate	1.91	77.10	31
Tailings	98.09	3.31	69
25% Solids			
Concentrate	1.4	75.51	23
Tailings	98.6	3.65	77
30% Solids			
Concentrate	0.9	73.91	14
Tailings	99.1	4.09	86

It can be seen from the data presented in Table 5 that at 5% solids, the grade of heavy minerals (TIM) is 55.87% and the grade has been increasing up to 25% solids (75,51% TIM), and at 30% solids, the grade is 73.91%. However, the recovery values are increasing from 5% (35.5% Rec) to 15% (45% Rec) and thereby decreasing the recovery values. At 20% solids concentration, the recovery value is 31%. Hence, a 15% solids concentration has been chosen as the optimum condition to carry out further experiments with groundwater and seawater. It may be noted here that in spiral concentration, especially for rougher concentration, it is aimed to minimize the values lost in the tailings. Therefore, in rougher concentrations, the maximum recovery has to be considered so that scavenging spirals will be reduced for the recovery of values from tailings. The effect of solids concentration on rougher spiral concentration to recover total heavy industrial minerals is shown in Figure 6.

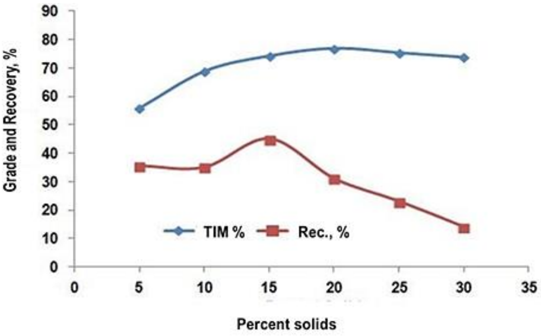


Figure 5 Effect of solids concentration on rougher spiral concentration to recover total heavy/industrial minerals

It is seen very clearly from Figure 5 that the TIM values are gradually increasing up to 15% solids, and thereby it is seen that the TIM is sharply decreasing. The recovery values are also gradually increasing from 5% solids to 15% solids and then gradually decreasing. Hence, the 15% solids concentration is considered the best condition to carry out further experiments using spirals with groundwater and sea water to recover the total heavy minerals and compare the test results on the effect of sea water spiral concentration.

3.4. Spiral concentration studies

Spiral concentration studies are carried out on low-grade beach placer samples (4.72% TIM) using fresh water and sea water to recover total heavy minerals from the beach sand. Prior to assessing the role of sea water on the recovery of total heavy minerals, an attempt is made to recover the TIM by a rougher spiral followed by a cleaner spiral set and a scavenging spiral set. Here, a cleaner spiral means that tailings should be free from values, whereas a scavenging spiral means that the TIM is free from gangue. The study reveals that cleaner spirals gave a better grade of 98.2% TIM, and scavenging spirals gave a grade of 92.1% TIM. The results achieved with sea water using the cleaner spiral route and scavenging spiral route indicate that 98.2% TIM has been achieved from the cleaner, whereas for the scavenging route, a grade of 93% TIM is achieved. This can clearly be seen in Tables 6 and 7.

Table 6 Results on the effect of ground water and sea water in cleaner spirals

Cleaner spirals using Ground water				Cleaner spirals using Sea water			
Rougher spiral Products	Wt. [%]	TIM [%]	Rec. [%]	Rougher spiral Products	Wt. [%]	TIM [%]	Rec. [%]
Concentrate	9.7	40.2	83	Concentrate	8.1	50.8	87
Tailing	90.3	0.91	17	Tailing	91.9	0.66	13
Cleaner spiral 1				Cleaner spiral 1			
Concentrate	26.8	90.2	60.1	Concentrate	30.9	98.1	59.6
Tailing	73.2	21.9	39.9	Tailing	69.1	29.7	40.4
Cleaner spiral 2							
Concentrate	80.8	98.2	87.9	Concentrate	28.6	98.1	94.2
Tailing	19.2	56.88	12.1	Tailing	71.4	2.4	5.8
Scavenging spiral 1							
Concentrate	17.1	98.2	70	-	-	-	-
Tailing	82.9	8.9	30	-	-	-	-

Table 7 Results on the effect of ground water and sea water in scavenging spirals

Scavenging spirals using Ground water				Scavenging spirals using Sea water			
Rougher spiral Products	Wt. [%]	TIM [%]	Rec. [%]	Rougher spiral Products	Wt. [%]	TIM [%]	Rec. [%]
Concentrate	1.5	93.15	30	Concentrate	1.7	94.2	34
Tailing	97.5	3.41	70	Tailing	98.3	3.18	66
Scavenging spiral 1				Scavenging spiral 1			
Concentrate	1.2	91.88	33.2	Concentrate	1.6	91.88	39.7
Tailing	98.8	2.31	66.8	Tailing	98.4	2.31	60.3
Scavenging spiral 2				Scavenging spiral 2			
Concentrate	1.1	91.88	32	Concentrate	1.2	91.88	33.3
Tailing	98.9	2.31	68	Tailing	98.8	2.31	66.7

Table 8 Summary of results on the effect of ground water and sea water in cleaner and scavenging spirals from a feed containing 4.72% TIM

Details	Cleaner Spiral with Ground Water	Cleaner Spiral with Sea Water	Scavenging Spiral with Ground Water	Scavenging Spiral with Sea Water	Details	Cleaner Spiral with Ground Water	Cleaner Spiral with Sea Water
Yield [%]	3.4	4.1	3.8	4.5	Yield [%]	3.4	4.1
Grade [%]	98.2	98.1	92.1	93	Grade [%]	98.2	98.1
Recovery [%]	71	85	74	89	Recovery [%]	71	85
Rougher	1	1	1	1	Rougher	1	1
No. of cleanings	2	1	-	-	No. of cleanings	2	1
No. of scavenging	1	1	2	2	No. of scavenging	1	1

The summary of the results on the effects of groundwater and seawater on cleaner and scavenging spirals is provided in Table 8, indicating that a product was achieved using fresh water from a rougher spiral, followed by two cleaner spirals containing 98.2% grade with 71% recovery and 3.4% yield from a feed sample containing 4.72% TIM. Further, a product was achieved using sea water from a rougher spiral, followed by one cleaner spiral and one scavenging spiral, containing 98.1% grade with 85% recovery and 4.1% yield from a feed sample containing 4.72% TIM. Experiments are repeated with scavenging spirals using the same feed material. The results achieved from scavenging spirals indicate that a product was obtained using groundwater from a rougher spiral, followed by two scavenging spirals containing 92.1% TIM with 74% recovery and 3.8% yield from a feed sample containing 4.72% TIM. Whereas, a product was achieved using seawater from a rougher spiral, followed by two scavenging spirals containing 93% grade (TIM) with 89% recovery and 4.5% yield from a feed sample containing 4.72% TIM. The summary of these results achieved on the recovery of total heavy minerals using cleaner and scavenging spirals with groundwater and sea water as media is shown in Figure 6.

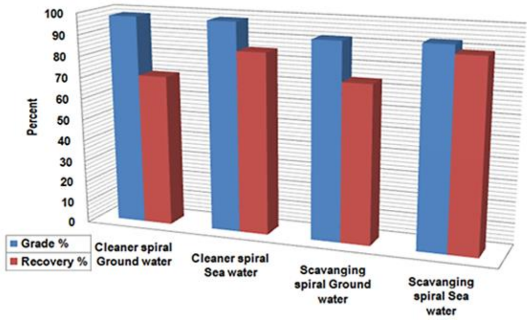
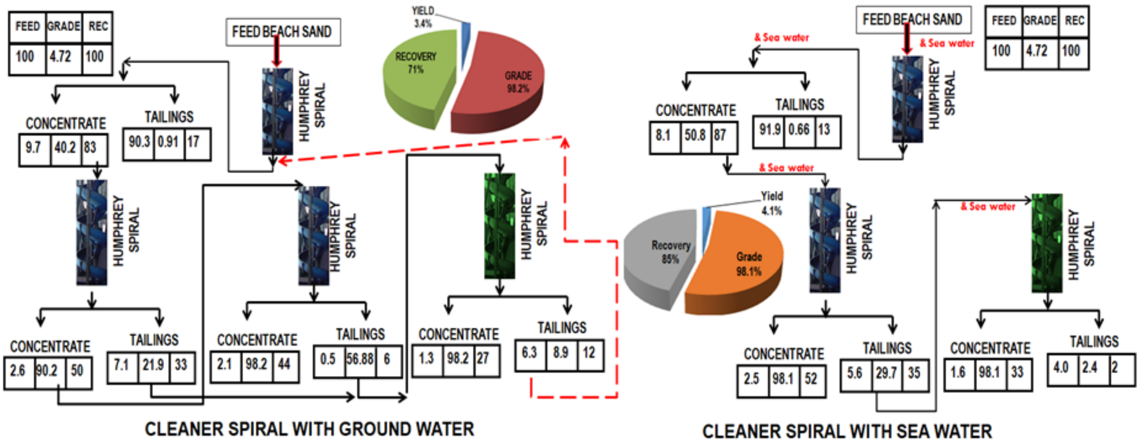


Figure 6 Summary of results achieved on recovery of total heavy minerals using cleaner and scavenging spirals with ground water and sea water as media



CLEANER SPIRAL WITH GROUND WATER

CLEANER SPIRAL WITH SEA WATER

Figure 7 Flowsheet with mass balance on recovery of total heavy/industrial minerals using cleaner spirals with ground water and sea water

A flow sheet with a mass balance on the recovery of total heavy/industrial minerals using cleaner spirals with groundwater and seawater, and a flow sheet with a mass balance on the recovery of total heavy/industrial minerals using scavenging spirals with ground water and sea water are shown in Figures 7 & 8. The data confirms the earlier findings in Tables 6 and 7 that with judicious combinations of a rougher spiral, two cleaner spirals, and one scavenging spiral using groundwater, the end product achieved contained 98.2% grade (TIM) and 71% recovery with a 3.4% yield. Whereas with judicious combinations of a rougher spiral, one cleaner spiral, and one scavenging spiral using seawater, the end product achieved contained 98.1% grade (TIM) and 85% recovery with a 4.1% yield. The data provided in Tables 6 and 8 implied that judicious combinations of a rougher spiral, two cleaner spirals, and one scavenging spiral using fresh water, the end product achieved contained 98.2% grade (TIM) and 71% recovery with a 3.4% yield. Whereas with judicious combinations of a rougher spiral, one cleaner spiral, and one scavenging spiral using seawater, the end product achieved contained 98.1%

grade (TIM) and 85% recovery with a 4.1% yield. The mineralogical analysis data of the cleaner and the scavenging spiral with groundwater and sea water are provided in Table 9.

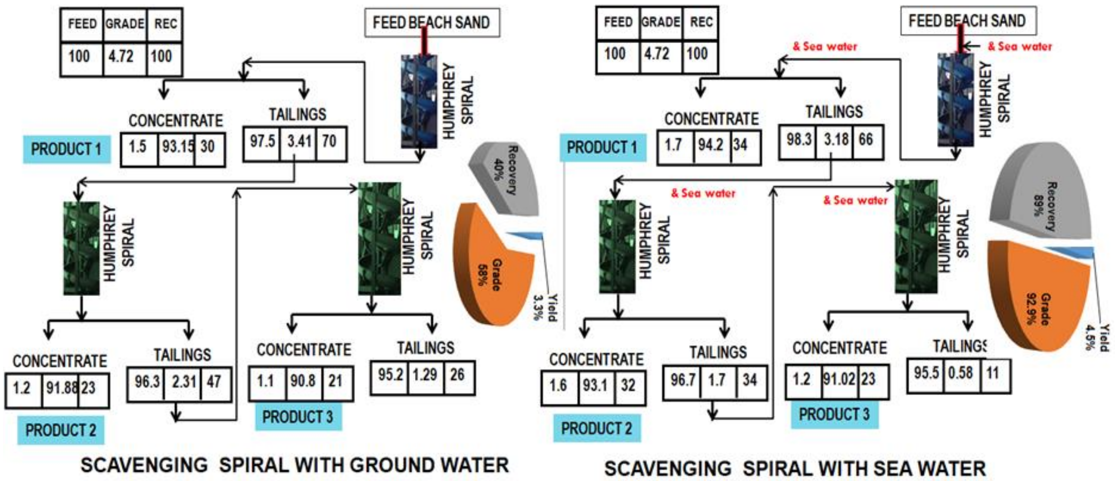


Figure 8 Flowsheet with mass balance on recovery of total heavy/industrial minerals using scavenging spirals with ground water and sea water

It is found that with the use of a cleaner spiral with groundwater, the percentage of ilmenite (33.54%), garnet (29.54%), sillimanite (32.81%), rutile (1.01%), zircon (0.53%), and monazite (0.51%) increases. Whereas the data obtained for the cleaner spiral with seawater shows the percentage of minerals such as ilmenite (33.55%), garnet (29.55%), sillimanite (32.55%), rutile (1.03%), zircon (0.72%), and monazite (0.70%). When comparing the data obtained by using a cleaner spiral with freshwater and a cleaner spiral with seawater, the difference in concentration for zircon and monazite, which are relatively finer minerals, is greater when seawater media are used for the recovery of the total heavy/industrial minerals. The trend is similar to scavenging spirals in the recovery of zircon and monazite. It is seen by using freshwater scavenging spirals that the zircon content is 0.68% and the monazite content is 0.65%. According to the data obtained for seawater scavenging spirals, the zircon content is 0.69% and the monazite content is 0.72%.

Table 9 Mineralogical analysis of cleaner and scavenging spirals with ground water and sea water

Details	Ilmenite	Garnet	Sillimanite	Rutile	Zircon	Monazite	Grade	Recovery
				[%]				
Cleaner spiral with ground water	33.54	29.84	32.81	1.01	0.53	0.51	98.24	71
Cleaner spiral with sea water	33.55	29.55	32.55	1.03	0.72	0.7	98.1	85
Scavenging spiral with ground water	31.49	28.12	30.27	0.9	0.68	0.65	92.11	74
Scavenging spiral with sea water	31.58	28.12	30.93	0.97	0.69	0.72	93.01	89

The use of freshwater spirals show that the zircon content is 0.68% and the monazite content is 0.65%. According to the data obtained for sea water scavenging spirals, the zircon content is 0.69% and the monazite content is 0.72%. It is concluded here that the use of sea water spirals can recover even relatively smaller minerals such as zircon and monazite, which are relatively sub-rounded to round and confirmed from a petrological study. Figure 9 shows the petrographs of ilmenite, garnet, sillimanite, rutile, zircon, and monazite present in TIM of the cleaner spiral.

A recommendation is made to justify the use of a mobile spiral concentrator all along the coast using seawater for recovering total heavy/industrial minerals and supplying to mineral sand industries after dewatering saline water from the total heavy minerals (Figure 10). It is essential to emphasize that the extraction of seawater from beach sand is critical for numerous applications, including the reduction of salinity in mineral separation facilities and the support of environmental remediation efforts. This process typically involves the removal of water from the sand, often employing methods such as gravity drainage, which makes use of perforated pipes or trenches to allow water to flow out. Another method is mechanical dewatering, which employs pumps or specialized equipment to extract water. The choice of method is determined by several factors, including the properties of the sand, the desired level of dryness, and the scale of the project. Effective dewatering is vital for maintaining concentration stability and ensuring the successful separation of individual industrial minerals, while also enhancing beach usability and mitigating the negative impacts of sea water on coastal ecosystems.

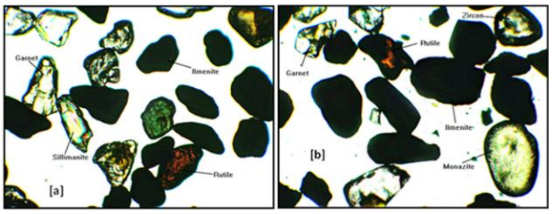


Figure 9 Effect of ground water and sea water on recovery in different heavy/industrial minerals using cleaner spiral concentrators
[a] Cleaner spiral concentrate using ground water and
[b] Cleaner spiral concentrate using sea water

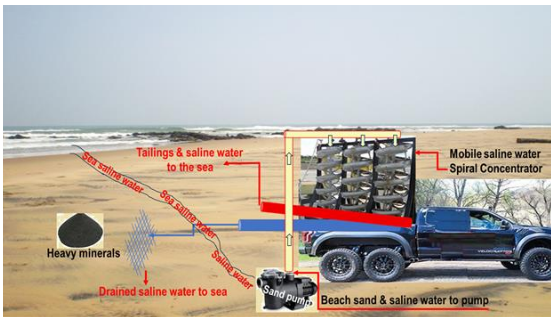


Figure 10 Proposed flow sheet to recover total heavy minerals using sea water with a mobile spiral concentrator along the coastline

Figure 10 makes it evident that a mobile spiral concentrator that uses trucks can mine sand, pump it to a spiral, dewater the resulting concentrate from the salty water, and then clean the saline concentrate at a mineral separation facility. The tailings and dewatered water remain on the coast without altering much on the mass balance of the coast's sand and water. In addition to improving the quality of life for those who work or live near the coast, this concept allows the mineral separation plant to purchase heavy mineral concentrate from the locals without interfering with their homes or settlements. It is concluded from the present investigations that mass balance on the recovery of total heavy minerals using cleaner spirals with freshwater and seawater revealed that seawater cleaner spirals gave a product containing 98.1% TIM with 85% recovery, whereas the freshwater cleaner spirals produced 98.2% TIM with 71% recovery from a feed sample containing 4.72% TIM. Thus, based on the benefits of utilizing saline water include reducing the demand for surface or ground water for preconcentration or bulk concentration of heavy industrial minerals, and improves the grade of all heavy or industrial minerals, it has been suggested in this study to recover bulk heavy industrial mineral concentrates utilizing a saline mobile spiral concentrator before transporting them to a mineral separation facility to recover cleaner mineral concentrates using freshwater by which both the mineral industry and labour will be benefited without disturbing the national economy.

4. Conclusions

In the present study, seawater was successfully used for the recovery of TIM. Mass balance on the recovery of TIM using cleaner spirals with freshwater and seawater revealed that seawater cleaner spirals gave a product containing 98.1% TIM with 85% recovery, whereas the freshwater cleaner spirals produced 98.2% TIM with 71% recovery from a feed sample containing 4.72% TIM. The petrological and mineralogical analysis data showed that application of seawater for wet concentration could recover even relatively smaller minerals such as zircon and monazite, which are relatively sub-rounded to round. Hence, it is recommended to use mobile spiral concentrators along the coast and use seawater for the recovery of TIM. The recovered TIM are transferred to the mineral separation plant after being purified from salt water and cleaned with groundwater. The use of mobile seawater spirals not only pre-concentrates the total industrial minerals but also decreases the use of freshwater in the plant, and further, it gives local employment opportunities for supplying the total industrial minerals by using seawater spirals, which also significantly improves the economic efficiency of the plant.

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EFEKAT MORSKE VODE NA GRAVITACIJSKI SEPARATOR ZA DOBIJANJE UKUPNIH INDUSTRIJSKIH MINERALA IZ ALUVIJALNOG NANOSNOG LEŽIŠTA SIPASURUBILI, ODIŠA, INDIJA

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Izvod

Ovo istraživanje razmatra prednosti korišćenja morske vode za dobijanje industrijskih minerala iz siromašnih rudnih ležišta koji se javljaju duž obalnog pojasa nalazišta plažnog peska Sipasurubili u državi Odiša, Indija. Uzorak sadrži 4,7% ukupnih industrijskih minerala (UIM). Ispitivanje pokazuje da se u industrijskom procesu može koristiti podzemna ili površinska voda za dobijanje koncentrata teških minerala sa 98,2% UIM i stepenom iskorišćenja od 71%, dok je upotrebom morske vode dobijen proizvod sa 98,1% UIM i iskorišćenjem od 85% iz ulaza uređaja za gravitacijsku separaciju. S obzirom na industrijski značaj aluvijalnih minerala u savremenoj tehnologiji i visoku potrošnju procesne vode, morska voda može predstavljati alternativu za koncentrisanje teških minerala niske koncentracije. Stoga se preporučuje upotreba mobilnih gravitacijskih koncentratora duž obale za UIM koristeći morsku vodu, kao i naknadno prečišćavanje teških minerala i odvodnjavanje slane vode pre transporta teških minerala u postrojenje za separaciju.

Ključne reči: *peščane dine, industrijski minerali, UIM, spiralni gravitacijski klasifikator, slana voda.*