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A novel, solar panel-based screenwashing apparatus for the bulk collection of microvertebrate fossils in the field

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Abstract: The contribution of microvertebrate fossils towards various paleobiological and geochemical studies are becoming increasingly more numerous and significant. As such, several methods have been developed for the extraction and collection of microfossils from bulk sediment. In the field, screenwashing relies on a sieve in a fluvial setting to passively wet sieve the fossiliferous sediment. Sampling in the field can be much easier as it alleviates the need to transport a large quantity of bulk sediment back to the home institution. However, the primary concerns of sampling bulk matrix in the field are access to a fluvial amenity and availability of sediment that can be successfully wet sieved. We encountered both issues at a locality where: 1) there was no access to any sort of fluvial feature, and 2) even with a man-made water containing feature, the clay-rich sediment at this locality created an impermeable layer in each screen box that clogged the screen, and prevented wet sieving. To overcome these challenges, we designed and implemented a two-part apparatus onsite in the field that relied on a solar-powered water transfer pump to cycle water throughout a system to provide fluvial agitation; whereby preventing the buildup of an impermeable clay layer, and allowing the processing and collection of microvertebrate material from this locality in the field. While there are numerous protocols and methodologies for the processing of microvertebrate material, the methodology we document in this study highlights another technique that can be utilized, and will hopefully prove useful to others encountering similar difficulties.

INTRODUCTION

The recognition and importance of microvertebrate fossils in paleobiological and paleoecological studies is increasing exponentially. Microvertebrate fossils can aid in reconstructing regional biotas (Hunt and Lucas 1993; Jamniczky et al. 2003; Wilson 2008; Avrahami et al. 2018), defining regional biostratigraphy (Lehman and Chatterjee 2005; Kilmury et al. 2023; Sarr et al. 2024), food web reconstructions (McKenna 2010; Vasile and Csiki-Sava 2010; McGuire 2023), taphonomic and sedimentological studies (Vasile and Csiki-Sava 2011; Tütken 2014; Rogers et al. 2016), as well as geochemical analyses (Wilson 2008; Rogers et al. 2010; Cullen and Cousens 2023). While manually collecting microvertebrate fossils directly from a microsite in the field still occurs, bulk sampling is more standard or commonplace.

In North America, many institutions – such as the Royal Tyrrell Museum of Palaeontology, the North Dakota Heritage Center & State Museum, or Macalester College – have devoted a significant portion of their labs and research programs specifically to the preparation and study of

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microfossils, and have developed exceptional onsite facilities for processing bulk matrix samples (Fig. 1). For institutions that cannot process bulk sediment at their respective facilities, screenwashing in the field is a tried-and-true process, and one that has changed little with time (see Hibbard's [1949] photo-documentation of the process that's largely indistinguishable from that used today). The optimal screenwashing setup in the field is one in which screen boxes can be placed in a body of water (lake, pond, river, canal, etc.) where they can be passively wet sieved. If agitation is needed, fluvial energy in such natural settings can provide the necessary action. On occasion, other substances such as kerosene or hydrogen peroxide have been used to aid in action for degradation besides water alone (see Ward [1981] and Wilborn [2009] application of kerosene and hydrogen peroxide on bulk samples). However, perhaps the most creative screenwashing setup that we know of entailed placing a sediment-loaded screen box adjacent to a roofline, which would be passively flushed with water every time it rained (B. Bossenecker pers. comm. 2024; wastewater from a gutter's downspout should conceptually work as well).

In the case of field localities lacking such fluvial amenities, screenwashing in a kiddie pool or stock tank can still achieve the desired results. However, in the case of sediment with a high clay content, agitation is often needed as the mesh screen can become blocked by an impermeable layer. Stirring, shaking, or manually agitating the contents can work, but that can take precious time away from other fieldwork, and manual agitation of the sediment slurry could inadvertently damage microfossils within. Alternatively, if on-site wet sieving is not possible, many institutions transport bulk matrix samples back to their home institutions for processing; unfortunately, that was not an optimal option at our location. Bulk sediment bags were carried out in frame packs at our location, each weighing ~23–34 kg; compared to the mere tens of grams of microfossils typically recovered from each (for examples of bulk sediment to fossil weight yields, see Haiar [2022]).

Beginning in 2023, the Phillip and Patricia Frost Museum of Science began paleontological fieldwork in the Judith River/Oldman and Dinosaur Park Formations near the town of Havre, Montana USA. While macrovertebrate fossils were the primary focus of the expeditions, microvertebrate fossils were also collected. With several microvertebrate localities identified, attempts were made to bulk sample and wet sieve in camp. Unfortunately, there were no readily accessible water features at or near camp, so we attempted to bulk wash in a kiddie pool. However, a high bentonitic clay content in the sediment inhibited successful retrieval of microfossils simply from soaking and screening in the kiddie pool. Approaches to alleviate the clay problem – such as adding baking soda – into the sediment mixture proved unsuccessful, thus it seemed that transporting bulk matrix was our only option.

However, before the onset of the 2024 field season, we decided to renew attempts to circumvent the previous season's issues of bulk sampling/on-site screenwashing. A solution and mechanism were reached by taking inspiration from the regional agricultural community. Many agricultural ranches in this region of the American West rely not only on wind-powered water pumps (via windmills), but also solar-powered water pumps. In the case of solar, power derived from the panels ultimately powers a pump that transfers water from a source to a stock tank for livestock. The transfer pump inadvertently creates agitation via the flow of water, and thus directly inspired the screenwashing apparatus we constructed and employed in the field.

MATERIAL & METHODS

Electrical considerations

First and foremost, please note that the apparatus constructed herein was designed in, materials ordered within, and used within the United States. Wattage and voltage for pieces of equipment and their technical specification may vary by country. All of the instructions below therefore follow US design and wiring, and we encourage those outside of the US wishing to implement this apparatus to first consult a certified electrician.

Screenwashing apparatus

This apparatus consisted of two sections: 1) the tilt bed, and 2) the pool stand (Figs. 2, 3). Throughout the description of our apparatus, we provide the specific names and models of equipment used. Alternative components can certainly be used, but we sought to provide the design and construction herein using our specified equipment.

Electrical components: The electrical components of the apparatus consisted of an ECO-WORTHY 200 Watts 12 Volt/24 Volt Solar Panel Kit (Fig. 4), a 12-volt deep cycle marine battery, and a FlowPac™ 12-volt 330 gallon-per-hour self-priming water transfer pump. Energy from the solar panels charge the battery, and the battery runs the transfer pump. The transfer pump would be turned on before leaving camp in the morning and switched off at the end of the day (for approximately 8 hours per day, six days a week throughout the months of June through August). All the electrical components were secured to the solar power controller using forked terminals. The transfer pump came with +/- crocodile clamps standard, but these were removed and replaced with +/- forked terminals (Fig. 5). To keep all of the electrical components weather secured, the battery, solar power controller, and transfer pump were kept in plastic totes in which holes were drilled for cords, hoses, and air flow (see the respective totes in Figs. 2, 3).

Figure 1. Examples of novel institutional-based bulk matrix processing setups. A, the soaking tank station at the Royal Tyrrell Museum of Palaeontology (RTMP). While the water can be drained from each large tank, the screenboxes float at the surface and are processed essentially following the same techniques and procedures implemented as if in the field. Photo of technician C. Capobianco with the RTMP's screenwashing station provided by T. Cullen. B, the motorized bike wheel setup in the lab of R. Rogers at Macalester College. This motorized construct entails the rotation of each wheel which raises and lowers each of the sediment-laden sieves within a bucket of water – analogous to the raising/lowering of a tea bag. Photo courtesy of R. Rogers and Macalester College. C, (i-iii) Soaking tanks at the North Dakota Heritage Center & State Museum that use a pneumatic line for aqueous agitation. Note that water in the top tank can drain to the lower tank, and from there wastewater is piped from each tank station to a drain. Photos courtesy of C. Boyd and the North Dakota Geological Survey.

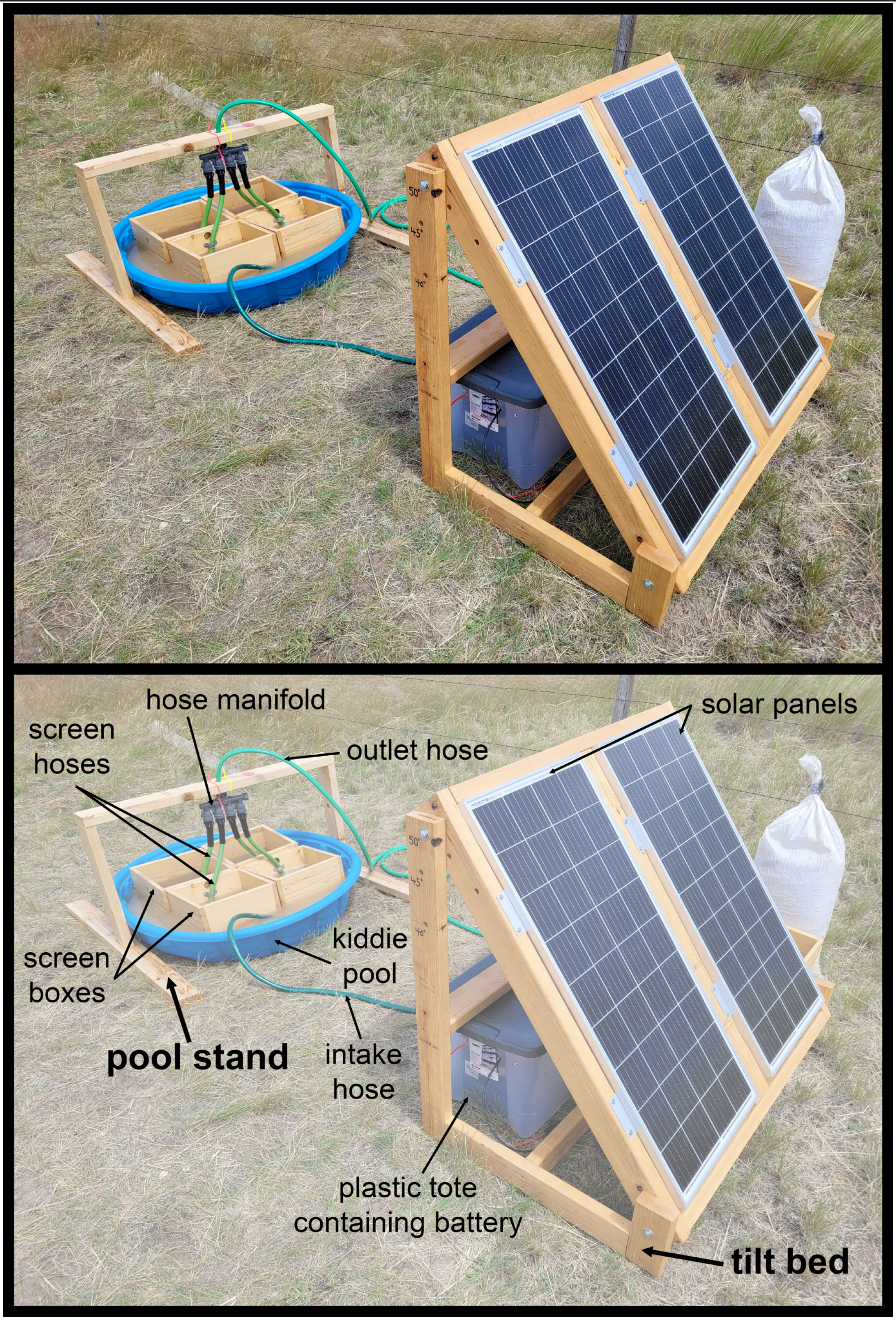

Figure 2. The solar-based screenwashing apparatus designed and implemented within this study. The apparatus in 'anterior' oblique view with all of the components and parts identified in the lower image. The main two sections – the tilt bed and pool stand in larger bolded font, and the other parts in smaller, non-bold font. As pictured fully operational and running on location in camp.

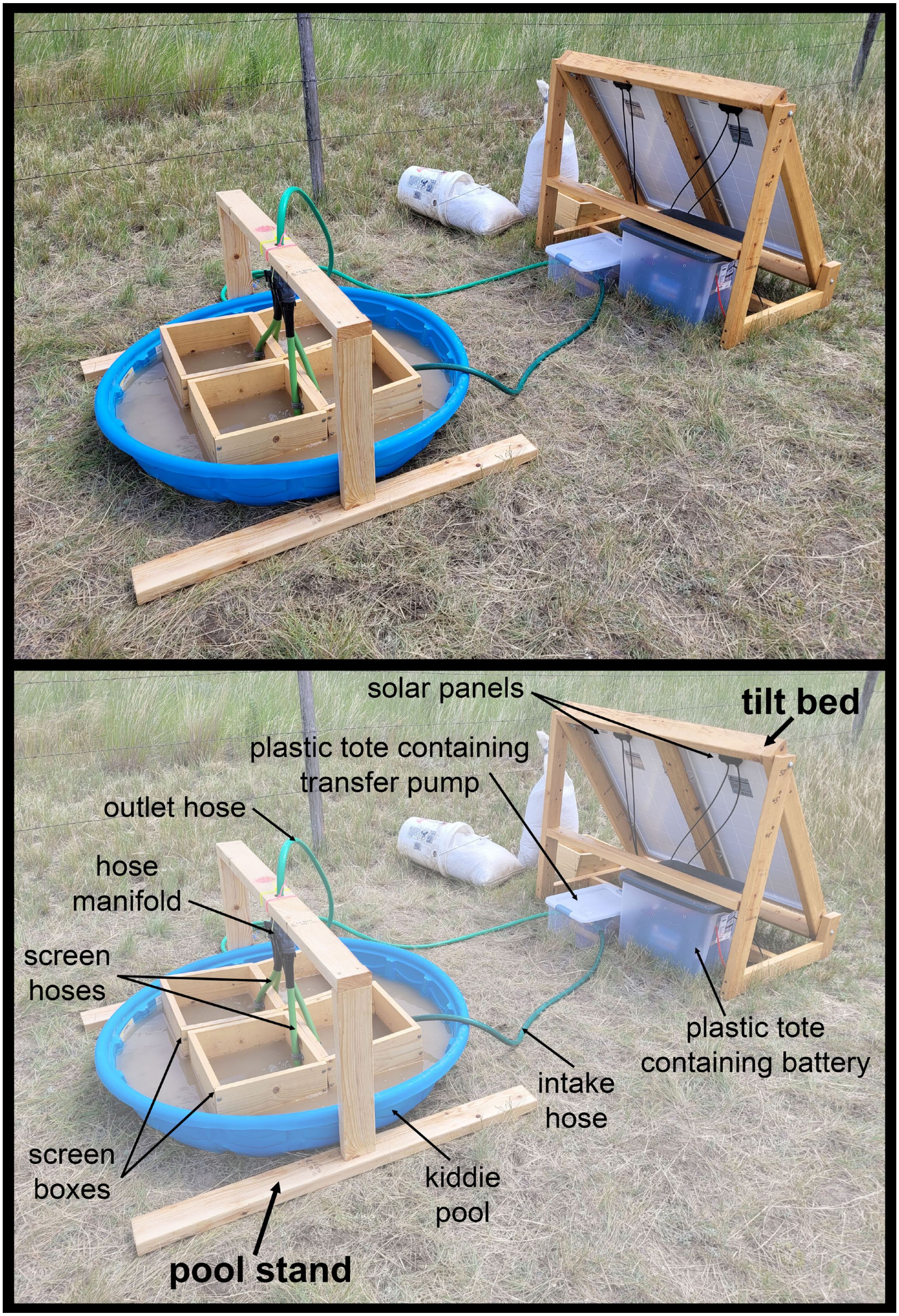

Figure 3. The solar-based screenwashing apparatus designed and implemented within this study. The apparatus in 'posterior' oblique view with all of the components and parts identified in the lower image. The main two sections – the tilt bed and pool stand in larger bolded font, and the other parts in smaller, non-bold font. As pictured fully operational and running on location in camp.

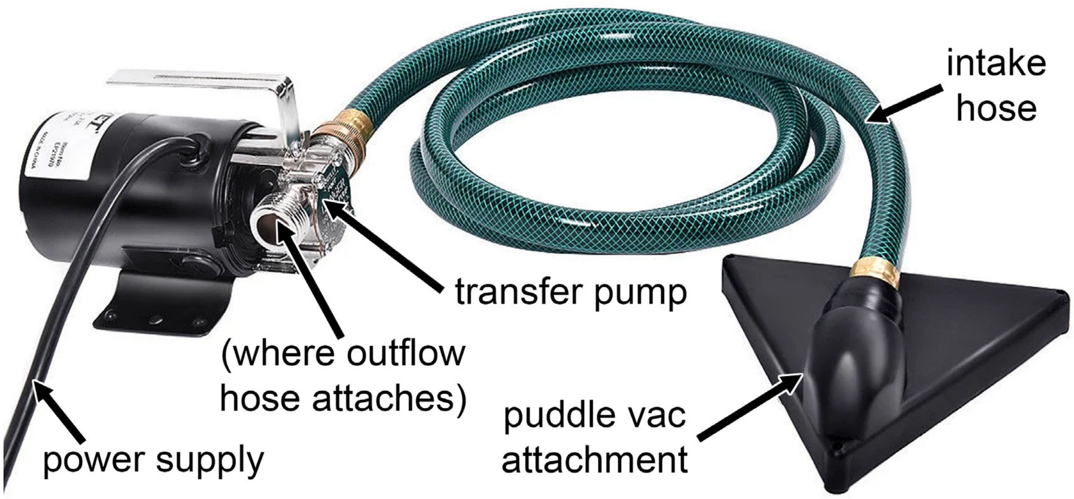

Figure 4. Example of a water transfer pump with the various components labeled. Note that the particular pump in this image is made by Costway, not ECO-WORTHY. However, the overall size, specifications, and most importantly, the component pieces are essentially identical.

Tilt bed: The tilt bed consisted of a 90° base and a pivoting frame designed to hold two ECO-WORTHY 200 Watts 12 Volt/24 Volt solar panels (Figs. 2, 3). The stand and the tilting frame were constructed out of 2x4" dimensional lumber coated in waterproofing polyurethane. A hole was drilled through the front of the stand and the bottom of the tilting frame on both sides, and a bolt was inserted into the hole. This bolt allows the base of the tilting frame to pivot. It is important for optimal solar collection and efficiency that panels be oriented perpendicularly 90° to the latitude where they are being used. Using a goniometer, the tilting frame was oriented to the appropriate angle (Fig. 6), and from there, a hole was drilled through the tilting frame and stand. In this construction, we chose the angles of 40°, 45°, and 50° which correspond approximately with latitudes from northern Utah, USA to southern Alberta, Canada. For optimal output, panels in the northern hemisphere should be facing South (and North in the southern hemisphere). For those wishing to make a more encompassing track for the orientation of the tilting frame, a single hole can be drilled in the tilt bed, and by placing a pencil or marker and moving the tilting frame from the minimum and maximum degrees, the path will be traced along the stand. Using a router, this path can be cut out providing a continuous arced degree track.

Pool stand: The pool stand consisted of a 90° I-shaped standing bracket that fit over a 109 cm diameter kiddie pool (Figs. 2, 3). Like the tilt bed, the pool stand was con-

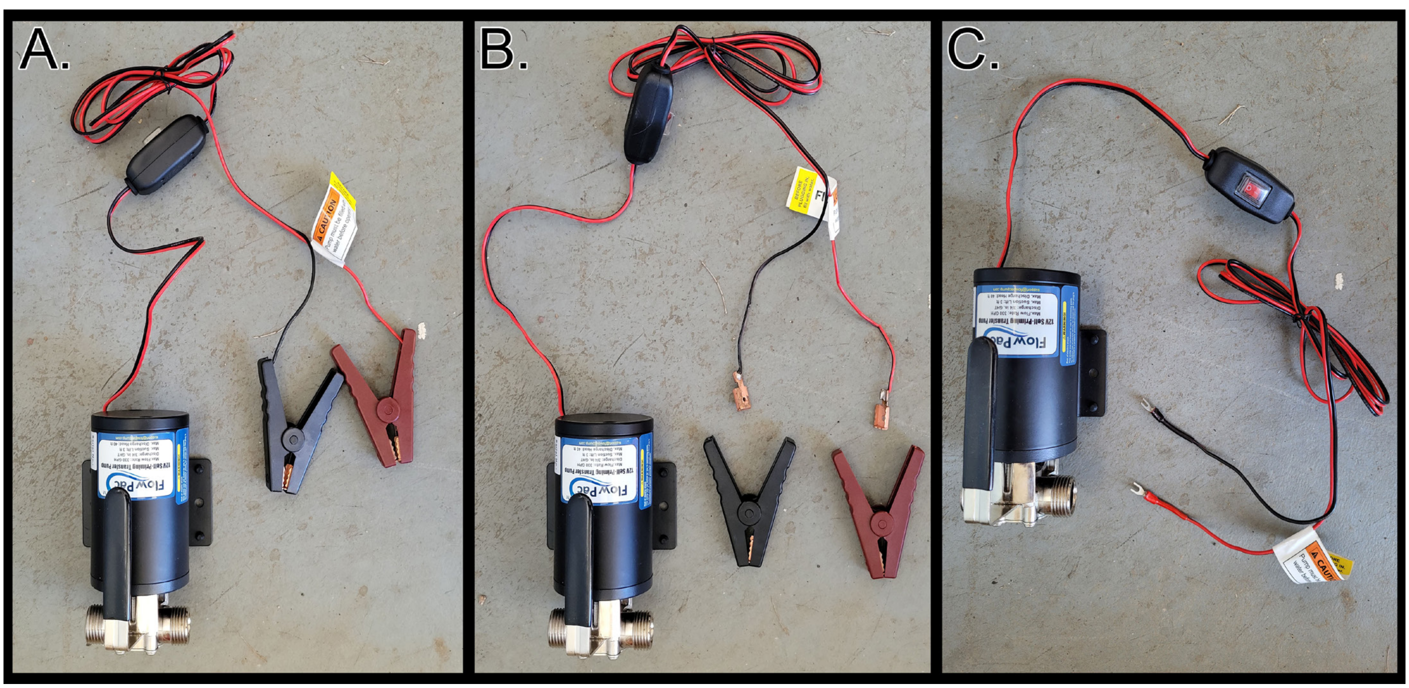

Figure 5. The simple process of removing the standard +/- crocodile clamps from the transfer pump,and replacing them with +/- forked terminals. A, the transfer pump with the standard crocodile clamps. B, removal of crocodile clamps. C, the replacement forked terminals.

structed out of 2x4" dimensional lumber coated in waterproofing polyurethane. From the transfer pump, an approximately 3 m garden hose attached to the pump outlet ran to the pool stand. Since the outflow of the outlet hose is also dependent on height (the higher up the flow has to be forced, the weaker the resulting outflow), the pool stand was positioned 55.5 cm above the ground. The end of the outlet garden hose ran through a corresponding diameter hole in the cross beam of the pool stand and was attached to an Ace Hardware™ 4-way garden hose manifold that was secured in place to the cross beam with zip ties. Attached to each connection of the hose manifold were additional garden hoses (cut to approximately 48 cm each), and each of these subsequent hoses – dubbed screen hoses – went to one of the screen boxes. From the inlet of the water transfer pump, the hose with the puddle vac attachment was simply placed in the pool to allow for intake suction. Thus, the water in the kiddie pool was sucked through the transfer pump to the hose manifold, and from there, moving water passed through each screen box, back into the pool to complete the cycle.

Screen boxes: Screen box sizes and construction can vary to any desired specifications, but ours were 30.48 cm long x 18.4 cm tall with a 17/14 mesh screen, and four boxes were operational in the kiddie pool at all times.

Regarding the volume of sediment placed in each screen box, as previously noted, large volumes quickly resulted in thick impermeable clay layers. Using a recycled food container as a scoop, we would manually add approximately 680 grams of bulk sediment to each screen box. This volume placed into the cycling water prevented the buildup of an impermeable clay layer. Assuming normal weather and running conditions, each loaded screen box could be washed within a ~24–48 hour period.

Periodically, depending on the viscosity of the sediment-laden water, settled sediment was removed from the bottom of the kiddie pool, and the water in the entire system was changed every three–four weeks. Sediment-laden slurry was manually scooped from the bottom of the pool every one–two weeks. When adding smaller volumes of water (approximately once a week), we ran it through the puddle vac attachment to simultaneously flush the hoses and pump system with clean water.

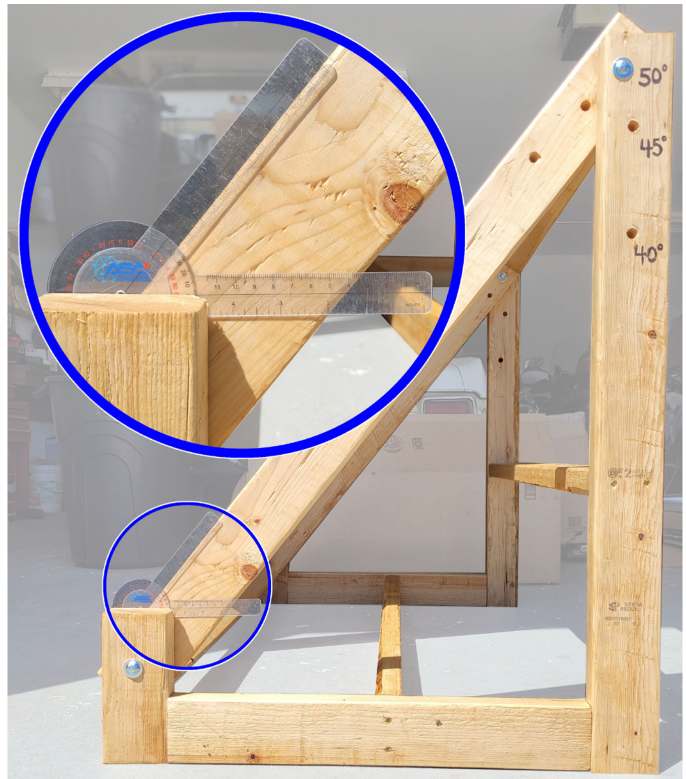

Figure 6. Construction of the tilt bed showing how a goniometer was used to determine the preset angles of the pivoting frame. Blue circle highlighting the location of the goniometer, with a zoomed-in view.

DISCUSSION

Considerations

It is important to note a few factors in the design and implementation of such solar-powered screen washing apparatuses: 1) The longer the hose from the outlet of the transfer pump, the weaker the resulting water pressure, 2) Likewise, even though hose manifolds can accommodate many additional hoses (up to five in the model we used), the more output hoses, the weaker the flow to each hose-screen box. In our configuration, four output hoses performed optimally (Fig. 3) In case stronger water pressure is required, a larger volume transfer pump can be substituted. However, a larger pump will require larger wattage solar panels.

A nearly identical design could be built in locations with readily accessible electrical capabilities using a sump pump in lieu of the solar panel-transfer pump configuration. Additionally, the "Clay Processing Machine" developed by Ward (1981) could be employed and powered in the field using this solar panel/transfer pump configuration. In this configuration, a container holds sediment-laden sieves that are positioned above the floor, and a fixed garden sprinkler continually wets the sediment while an oscillating sprinkler provides the agitation. Microfossils remain in the screen boxes, while heavy sediment settles to the bottom of the container, and an overflow drain along a top edge allows the excess water to flow out. A solar-powered water transfer pump could hypothetically provide the needed energy, but because of the psi needed to activate the sprinklers, such a device should be tested prior to field implementation.

'Refugium'

In the case of a heavy sediment-viscous slurry, one could opt to design a 'refugium' of sorts that would allow suspended sediment to collect in the main pool, while less sediment-laden water would be transferred to a secondary pool where this cleaner water would be pumped and cycled back through the whole system via the puddle vac attachment. Such a 'refugium' could work, but in a simple test using our configuration, we found that water was sucked through the puddle vac attachment far faster than water could be siphoned from the main pool to a refugium (in this test a 19-liter bucket). Again, such a 'refugium' could possibly work, but it would likely require a secondary pool at least equal to, if not larger than, the main pool holding the screen boxes.

CONCLUSIONS

The solar panel-transfer pump configuration outlined above performed optimally throughout the 2024 field season, and in lieu of readily accessible fluvial features, still performed well in passive-based bulk sediment screenwashing. While the entire apparatus constructed herein costs approximately $400 USD, admittedly, the acquisition, construction, transportation, and storage of this apparatus may be beyond the desired means and abilities of other field crews. However, compared with other costs incurred during fieldwork (e.g., food, fuel, supplies, etc.), the ability to passively process the samples on site, largely unmonitored, with this setup would make this investment worthwhile – especially considering the extra labor-hours that would be consumed with manual processing and the extra transportation-related expenses for off-site processing. As we experienced, presumably other paleontological expeditions have encountered similar sampling challenges. As such, the apparatus described herein represents but another means by which microvertebrate fossil material can be sampled en masse. Additionally, while this screenwashing setup was constructed and implemented on location in the field, it could equally be used at facilities that might not have the space requirements for washing tanks, and/or possibly be 'mobile' and demonstrated at different locations for educational outreach.

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