The approximate nature of radiative transfer equation (RTE) leads to a bunch of considerations on the effect of “dependent scattering” in random media, especially particulate media composed of discrete scatterers. In the last few decades, results usually indicate that those deviations from the RTE (combined with ISA) lead to experimental and exact numerical results due to electromagnetic wave interference. Here we theoretically and numerically demonstrate the effect of dependent scattering on absorption in disordered media consisting of highly scattering scatterers. By making comparison between the independent scattering approximation-radiative transfer equation (ISA-RTE) and the full-wave coupled dipole method (CDM), we find that deviations between the two methods increase as scatterer density in the media increases. The discrepancy also grows with the optical thickness. To quantitatively take the dependent scattering effect into account, we develop a theoretical model using a quasicrystalline approximation (QCA) for the field and distorted Born approximation (DBA) for the intensity to derive dependent-scattering corrected radiative properties, based on the path-integral diagrammatic technique in multiple scattering theory. The model results in a more reasonable agreement with numerical simulations. The present work has profound implications for coherent scattering physics in random media with absorption, correctly modeling light absorptance in random media and interpreting the experimental observations in various applications for random media such as micro/nanofluids, structural color generation, etc.