Reductive dechlorination is a major degradation pathway of chlorinated ethenes in anaerobic subsurface environments, and reactive kinetic models describing the degradation process are needed in fate and transport models of these contaminants. However, reductive dechlorination is a complex biological process, where many microbial populations including dechlorinating, fermentative, methanogenic, iron and sulfate reducing, interact. In this article the modeling approaches and the experimental data needed to calibrate them are reviewed, classified, and discussed. Model approaches considered include first order kinetics, Monod kinetics to describe sequential reductive dechlorination and bacterial growth, and metabolic models which simulate fermentation and redox processes interacting with reductive dechlorination processes. The review shows that the estimated kinetic parameters reported vary over a wide range, and that experimental microbial data are scarce. Very few studies have been performed evaluating the influence of sulfate and iron reduction, and contradictory conclusions on the interaction of redox processes with reductive dechlorination have been reported. The modeling approaches for metabolic reductive dechlorination employing different descriptions of the interaction between redox and dechlorination processes and competition for hydrogen are classified. The current concepts lead to different results, suggesting a need for further investigations on the interactions between the microbial communities performing dechlorination and redox processes, including the establishment of biomarkers quantifying dechlorination, and on geochemical characterization. Finally, the relevance of laboratory data and the development of practical modeling tools for field applications are discussed. Biotechnol. Bioeng. 2013; 110: 1–23. © 2012 Wiley Periodicals, Inc.